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FINAL REPORT

ADAPTABILITY OF AIRLINE-TYPE AVIONICS ACQUISITION PROCESSES TO ADVANCED LANDING SYSTEM PROCUREMENT

October 1974

Prepared for

TRACALS SPO
Electronic Systems Division
Air Force Systems Command
L. G. Hanscom Field
Bedford, Massachusetts 01730

under Contract F09603-73-A-4392-0004

ARINC RESEARCH CORPORATION

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FOREWORD

The four-month study reported on herein was performed by ARINC Research Corporation under Contract F09603-73-A-4392-0004 for the Traffic Control and Landing Systems (TRACALS) System Program Office (SPO) Electronic Systems Division of the Air Force Systems Command. The purpose of the study was to evaluate the feasibility and potential cost benefits of developing and applying ARINC Characteristic-type TRACALS specifications for a future Advanced Landing System (ALS) avionics procurement.

ARINC Research Corporation acknowledges the wholehearted cooperation received during this effort from the government personnel, airline representatives, and equipment vendors (many of whom are identified in Appendix H of this report). We appreciate particularly the guidance and support provided by the contract monitors -- Major John Martel, Captain Herbert Laflamme, and Mr. Seward Norris.

A wealth of information concerning AEEC activities and Characteristic development and application, as well as helpful suggestions for the report, was provided by William T. Carnes, Chairman of the AEEC.

Contributions from a number of ARINC Research personnel were extremely helpful in establishing the approach to the program and unifying its many aspects. Howard Kennedy's efforts have been particularly valuable. In addition, important contributions were made by C.R. Knight, A. Pazornik, J. Hinson, B. Retterer, H. Balaban, J. Reese, and C. Wigle.

The views and conclusions presented in this report are those of the authors and do not necessarily represent expressed or implied official policies of the U.S. Government.

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ABSTRACT

ARINC Research Corporation evaluated the feasibility and potential cost benefits of developing and applying ARINC Characteristic-type TRACALS specifications for a future Advanced Landing System (ALS) avionics procurement. This report presents the results of the evaluation; it describes the commercial air carriers' procurement process and the role of the Characteristic, comparing elements of military procurement with parallel elements of commercial procurement.

Performance characteristics of military and commercial equipments are evaluated, and cost and reliability comparisons are made on the basis of available data. Problem areas associated with military use of the commercial process are also discussed, with emphasis on equipment-installation problems. Finally, a recommended approach to developing an ALS Characteristic is presented.

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SUMMARY

1. BACKGROUND

There is increasing emphasis throughout the Department of Defense on reducing the overall costs and improving the effectiveness of military equipments. One of several avenues being explored to achieve this result is the adaptation and use of commercial procurement practices. In view of the reported success achieved by the commercial airlines in purchasing cost-effective avionic equipments, ARINC Research Corporation was awarded a four-month contract to investigate the feasibility and possible benefits of adapting these practices to Air Force use.

The effort was sponsored by the Traffic Control and Landing Systems (TRACALS) System Program Office (SPO), Electronics Systems Division, Air Force Systems Command. It was oriented toward an investigation of the applicability of such procedures to the procurement of a future Advanced Landing System (ALS). The present plan is to procure three different configurations of the ALS -- Austere, Standard, and Advanced -- which are to meet, respectively, International Civil Aviation Organization (ICAO) Category I, II, and III landing situations.

2. ASSUMPTIONS

Two simplifying assumptions were made at the outset of the study:

- The airline avionics-acquisition process does not include a funded or controlled equipment-development program. The only objective is purchase of *production* equipment. In this analysis, therefore, no development effort is considered. The military, FAA, and civil groups are participating in an extensive ALS/MLS development program. It is assumed that *all* development will have been completed under that program and that the specifications considered in this report will deal with procurement of off-the-shelf production items only.
- Full-life warranty will be used instead of organic Air Force maintenance. This assumption, however, does not preclude the use of alternative warranty approaches. Full-life warranty offers the extreme condition for the analysis. Other alternatives,

involving a combination of military and airline procedures, would require a series of analyses (including life-cycle-cost analyses) that go far beyond the limits of the time and manpower allocated to this study. Further, suitable data are not available to permit an adequate life-cycle-cost analysis to be conducted at this time. (It is expected that the Air Force will have developed such data from current programs to permit valid analysis prior to the procurement.)

3. APPROACH

The contract efforts involved reviewing the airline procurement process and comparing it with the current military process. Data on comparable equipments procured under each process were assembled and evaluated.

Elements of the commercial approach were then considered in terms of their applicability to the military process. Anticipated legal, regulatory, technical, and other difficulties were examined and solutions proposed. A tentative military approach for use of the commercial practices was developed and discussed with various procurement and management personnel in the military, airlines, and manufacturing organizations. On the basis of comments and suggestions received, a proposed military process was formulated.

4. OVERALL CONCLUSIONS

The commercial airlines employ an avionics acquisition process that has been effective in providing them with high-quality equipment at competitive prices. The overall process, in which the Characteristic represents only one element, is based on the existence of competition throughout the useful life of the equipment. By contrast, in the military situation, the competitive factor is significantly reduced following the award of a production contract. The continuing competition in the airline environment is a basic factor on which the entire procurement process rests.

The two processes and some equivalent equipments procured under each were compared. While cost and reliability data were not unequivocal, they suggest that benefits accrue to the airlines in these areas. In addition, consideration of the overall airline and military environments indicates that elements of the airline process are potentially adaptable to military procurements.

In general, it was concluded that it is feasible and can be cost-effective to develop and apply ARINC Characteristic-type specifications to the procurement of the three ALS configurations. The approach presented in this report will be most effective if implemented immediately to permit completing all necessary activities by the currently projected FY 1978 production-decision date.

5. SPECIFIC CONCLUSIONS

The following specific conclusions were reached:

- Indisputable data on cost and reliability comparisons of military versus commercial airline avionic equipment are not available. Nevertheless, the total weight of available data clearly supports the experimental application of airline avionics acquisition practices, including development and application of Characteristic-type specifications, to the ALS program.

- There are no insurmountable formal barriers to Air Force use of airline specification development or application practices. In an organization the size of the Air Force, human resistance to change is seen as the largest obstacle to the success of even an experimental application of airline practices.

- Space availability represents a major installation problem in other than some transport aircraft. Further, concurrent installation of ILS and ALS avionics will present a severe space problem in many aircraft types regardless of the standardization approach taken. The ALS avionics/automatic flight control system interface represents another major installation problem in those configurations requiring coupled approach and landing capabilities. To provide sufficient information upon which the committee responsible for Characteristic development can base size, cost, and performance trade-offs, a thorough space-availability and system-compatibility study of anticipated USAF ALS installations must be performed.

- Environmental factors (vibration, temperature, and altitude) will require special installation considerations in high-performance aircraft. Overall cost-benefit considerations beyond the scope of this study may dictate nonstandard equipment for such limited-quantity, high-performance applications.

- Three separate Characteristic-type specifications are considered necessary -- one each for the Austere, Standard, and Advanced ALS avionics. The Advanced system requirements should be so similar to airline needs that separate development of a Characteristic by the Air Force would not be required. Suitable ancillary documents for procurement would, however, be necessary if an airline-developed specification were used.

- The number of military standards and specifications normally referenced in military procurements can be substantially reduced if an ARINC-type Characteristic and associated procurement practices are used. The major reduction in standards and specifications is associated with elimination of design, parts, and process control.

- A major reduction in contractor data requirements can be achieved if the overall acquisition approach associated with the use of ARINC Characteristics is followed. Data-requirements reductions are also related to elimination of detailed equipment design and production control.

- Staffing of the committee charged with developing the Characteristics will require careful consideration of capabilities as well as continuity. The importance of these personnel selections should not be underestimated.

- Despite uncertainties and anticipated problems, no impossible barriers are evident, and thus the application of ARINC-type Characteristics and associated procurement practices is concluded to be feasible. Potential cost-benefit advantages as stated in the first conclusion clearly support, at the very least, the experimental application of the approach as an aid to future Air Force and DoD decision-making on improving procurement practices.

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CHAPTER ONE

INTRODUCTION

1.1 ALS PROGRAM DESCRIPTION

The current Instrument Landing System (ILS) in wide use by the aviation community as an all-weather terminal guidance and landing aid has demonstrated technical deficiencies that limit its application. As a result, an international exploration of viable alternatives that can replace the present system has developed. The Radio Technical Committee for Aeronautics (RTCA) Special Committee 117 has developed a set of technical recommendations[17]* for a new system that would offer sufficient improvement potential to justify considering it as an ILS replacement. The United States is currently evaluating candidate techniques, one of which is to be selected in late 1974 or early 1975 as the U.S. recommendation for ICAO consideration as an international standard. This system has been designated the National Microwave Landing System (NMLS).

The nature of the worldwide USAF mission of defense of the United States requires that USAF aircraft use not only U.S. military and civil air traffic control and navigation facilities, but also those civil and military facilities of allies and facilities that may be available from nonaligned nations. The USAF has stated as policy its decision to continue to implement those approach and landing aids that are interoperable with standard national and international civilian aviation systems. Equipment to satisfy the Air Force requirements in the context of an international microwave landing system will be evaluated in the Advanced Landing System (ALS) program currently being implemented by the Air Force Systems Command.[84]

When the NMLS is implemented, the Air Force will be faced with a major acquisition program to equip their aircraft fleet with ALS avionics. An avenue that may have considerable promise for minimizing the required investment is the creation of a buyer's market in which the monopsonistic (single buyer and multiple sellers) aspect of the military process is employed to encourage continuous competition among manufacturers.[21] It is generally agreed that competition between suppliers throughout the life cycle is the principal factor in lower acquisition costs.[10]

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*Superscripts refer to numbered entries in the Bibliography, Appendix H.

1.2 PROJECT OBJECTIVES

An approach that may offer potential for developing the desired competition involves the adaptation of some commercial airline procurement procedures -- principally the development and use of ARINC Characteristic-type specifications. The Characteristics define mechanical and electrical interfaces, plug and pin locations, form, fit, and function; they do not constrain the manufacturers' designs of internal system hardware. The use of ARINC Characteristics permits the air carriers to procure on a more favorable basis than would otherwise be possible since if one manufacturer's avionics equipment does not meet airline needs, a suitable alternate can be found from another that is compatible with the existing installation in form, fit, and other interfaces.

The contract effort reported on herein was directed toward investigating the feasibility of applying some aspects of the airline approach to avionics acquisition as a means of minimizing Air Force ALS avionics acquisition costs. The four principal task efforts were as follows:

1. Examine current USAF and DoD procurement regulations for restrictive or prohibitive language concerning development and utilization of an ARINC Characteristic-type specification. Evaluate the procurement significance of any identified conflicts and make appropriate recommendations for resolving the conflicts to the TRACALS SPO.
2. Investigate similar applications of ARINC Characteristics, including those used for procurement of ILS avionics, and determine the impact of the Characteristic on equipment performance, quality, and cost. Include an appraisal of the requirement for and use of ancillary procurement documents such as RTCA Minimum Performance Standards and manufacturers' equipment specifications.
3. Identify and evaluate potential significant installation problems that could be a deterrent to the formulation of ARINC Characteristics for the procurement of Austere (Cat. I), Standard (Cat. II), and Advanced (Cat. III) ALS avionics as applicable to the various classes of aircraft in the USAF inventory. Include consideration of potential interface problems with existing aircraft interwiring, autopilot couplers, autopilots, on-board computers, cockpit instrumentation, etc. Also determine if, where, and why more than one ARINC Characteristic will (or may) be required to cover the full range of anticipated ALS avionics applications.
4. Identify, and evaluate the impact of, MIL-SPEC provisions that will have to be retained in the ALS Characteristic(s) to ensure that equipment performance and quality goals are met. Also review typical data requirements and identify the minimal data items required for effective management and control of the program. Utilize the outputs of these investigations in determining the feasibility of purchasing commercial-grade avionics.

1.3 PROJECT APPROACH

The basic approach to achieving the required results under this contract involved analyzing the airline and Air Force processes -- not simply the two principal documents influencing these processes. Initially, commercial procurement practices were reviewed and compared with Air Force practices to identify similarities and differences. The comparisons addressed regulatory/legal, technical (including cost), and other factors.

Regulatory/legal factors included applicable statutes, regulations, procurement policy, organizational control, and management visibility. Procurement policy included such factors as DoD and USAF directives, airline procedural and support practices, maintenance of competition, and assurance of quality and performance. Organizational control addressed interpretations of the DoD and USAF directives at the Command, Division, and lower organizational levels, and compared them with airline control requirements.

Although no legal opinions were formulated, factors related to ALS specification development and application were evaluated and comments provided. Anti-trust and conflict-of-interest considerations were reviewed for their applicability to potential Air Force adaptation of the ARINC Characteristic-type procurement process.

Technical investigation included an assessment of three aircraft types as examples of the range of installation considerations to be addressed. The aircraft types were related to the three proposed ALS configurations: Austere, Standard, and Advanced. Factors such as interface, environment, space, power, and support were noted for the A-7, C-141, and T-37. Limited data on the F-15 were also reviewed. In addition, the performance, quality, and cost attributes of airline and military avionic equipments were tabulated and compared to identify possible benefits of the two processes. These results were used to evaluate documentation and procedural requirements that offer potential for minimizing the acquisition cost of high-quality avionics.

A number of other factors that can be expected to influence the adaptation of a commercial-type process to the Air Force application were considered. These include resistance to change, as well as such factors as the time associated with development of Air Force specifications and characteristics and the establishment of free exchange between participants in open meetings.

Several basic assumptions were made early in the program to limit the effort to the constraints of the time and funds allocated:

- Use of full-life warranty was assumed. This permitted the minimization of requirements for supportive specifications, statement-of-work items, and contractor surveillance and reporting. Furthermore, this assumption need not be adhered to when the procurement occurs or the contracted items are delivered. If more definitive information became available prior to contract award, alternative limited

Reliability Improvement Warranty (RIW) could be included in any contract, or organic support could be used. Arrangements for acquisition of the necessary organic-maintenance data could then be negotiated at that time (permitting this part of the procurement to be priced separately and subjected to a cost-effectiveness evaluation).

- It was assumed that all development work and adaptation of designs to USAF requirements would be completed prior to equipment acquisition. The contract would be for production items *only*.
- It was assumed that equipment acquisition would be on an off-the-shelf basis, with deliveries scheduled to permit installation in the aircraft as they were programmed for the normal overhaul/modification process (or delivery in the case of new aircraft). It was also assumed that no special high-volume production would be encouraged or funded by the government. If a single manufacturer was incapable of providing the needed equipment, then multiple awards could be made to meet the necessary acquisition schedules.

The execution of the tasks involved the acquisition of data, preliminary analysis, identification of potential problems, interviews with appropriate personnel in the military and commercial sectors, and the preparation of a final report documenting the apparent absence of problems; the existence of problems, with proposed solutions; and the existence of problems for which no current solutions are apparent.

The procedures followed in each of these task efforts are presented in Appendix A.

1.4 REPORT CONTENT

Basically, Chapter Two describes the commercial air carriers' procurement environment, the procurement process involved, and the role of the Characteristic in the process. In Chapter Three, elements of the military procurement process and the associated specifications are compared with comparable elements of the commercial process. An evaluation of performance characteristics of military and commercial equipments is presented in Chapter Four. Additionally, cost and reliability comparisons are made on the basis of available data. Chapter Four also itemizes and discusses some problem areas associated with military use of the commercial process. Particular emphasis is given to problems associated with equipment installation.

In Chapter Five, an approach to development of an ALS Characteristic is presented. Overall conclusions concerning the applicability of the commercial approach to the ALS procurement are offered in Chapter Six.

The appendixes to this report present details of ARINC Research contract activities performed in response to the Statement of Work, items associated with the commercial process, and AN/ARN-XXX TACAN references.

Technical descriptions of representative Air Force and airline ILS equipment are provided, together with ALS/aircraft installation data and the installation/integration "requirements" of an ARINC Characteristic. Finally, a bibliography and source list is presented.

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CHAPTER TWO

CURRENT AIRLINE ACQUISITION PROCESS

2.1 BACKGROUND

Airline procurement is truly competitive. Each airline buys its own equipment; there are few "quantity" procurements; and each airline buys equipment from a manufacturer of its own choice -- not necessarily determined by low-dollar bid. In this chapter, these and other aspects of the airline avionics acquisition process will be examined as background for the findings presented in a later chapter.

2.1.1 Evolution of the Process

The current airlines procurement process -- in which avionic equipments to be acquired are described by ARINC Characteristics and other supporting documents -- was developed over a period of about 35 years. A brief review of its history will help to evaluate the process in the proper perspective.[1,2]

In the mid-1930s, when scheduled flights were confirming the emergence of an airline industry, and radio communications were becoming compulsory for the operation and control of aircraft, the United States Bureau of Air Commerce began writing equipment specifications for the new industry.

By the late 1930s, the Civil Aeronautics Authority had acquired a staff of specification writers and was producing both air traffic control regulations and equipment specifications. At about the same time, the airlines and manufacturers were becoming dissatisfied with the equipment specifications produced for them by the government, and the airlines launched their own efforts. The task was assigned to Aeronautical Radio, Inc. (ARINC), the airline-dedicated communications company. The onset of World War II and the preoccupation of the Civil Aeronautics Authority with other matters probably averted a confrontation over the preparation of airline specifications.

After World War II, during the rapid expansion of the air transport industry, avionics procurement became a major task for the small ARINC structure. At the same time, the airlines were developing sizable procurement staffs of their own. By late 1947 the airline companies that owned ARINC decided to have ARINC continue writing specifications but to move the procurement of avionics into the airlines themselves. This decision broadened the competition among the avionics suppliers who had emerged from the

war, and it highlighted the need for interchangeability of equipments. In turn, these multiple pressures intensified the cooperation of airline representatives and equipment manufacturers in the definition of new "black boxes". Thus, in 1949, the Airlines Electronic Engineering Committee (AEEC) was established, with its broad spectrum of technical participation.[41] It has remained a dynamic body during the 25 years of its existence.

2.1.2 AEEC Structure

Because of the AEEC's success in preparing Characteristics (or specifications) for airline avionics, the committee frequently has been described as "a committee that works". The full committee consists of 31 persons, including the four furnished by ARINC to function as Chairman and provide the secretariat functions. However, only 22 of the committee members are voting members. Table 2-1 lists the AEEC membership. Many other interested parties, representing wide public interest, attend the meetings. Typical attendance has exceeded 200 contributing observers from airlines, governmental regulatory groups, military agencies, avionics equipment and airframe manufacturers, and members of the press.

Table 2-1. AIRLINES ELECTRONIC ENGINEERING COMMITTEE (AEEC)

Voting Members	Number
U.S. Scheduled Airlines	14
European Airlines Engineering Committee	6
Canadian Airlines	1
General Aviation	1
Total Voting Members	22
Advisory (Nonvoting) Members	**Number**
ARINC (Chairman and Secretariat)	4
Air Transport Association of America	2
International Air Transport Association	1
U.S. Military	2
Total Nonvoting Members	9

2.1.3 Constraints

The airlines' success in obtaining avionics that perform reliably and safely at a competitive cost has made certain elements of their procurement approach attractive candidates for ALS application. The remainder of this chapter examines elements of the airline process, a basic step in any consideration of adapting commercial processes to military use. The steps leading to the acquisition of avionics are reviewed, starting with the preparation of the production specification. Establishment of the requirement and the initial research and development effort are excluded, as a basic fact in airline procurement. They do not fund R&D. A similar

requisite will exist for the ALS program, since the present research and development effort in microwave landing systems by the FAA and military organizations will proceed concurrently with the ALS Committee effort. This will provide an adequate technical base for establishing suitable production-only specifications.

2.2 CHARACTERISTIC DEVELOPMENT

2.2.1 Initiation of the Characteristic

When sufficient justification for the development of an ARINC Characteristic has been established (i.e., the operational necessity justifies the expenditure of funds for equipment acquisition), the AEEC, by airline consensus, will establish a subcommittee to draft the document.[25] To produce this document, which eventually will become an ARINC Characteristic, a subcommittee Chairman is named (usually from the airline with the greatest interest in the project). The subcommittee meetings attract interested airlines, manufacturers, and others to compile the first draft. The initial "straw man" draft may be the product of one of the avionics manufacturers, the AEEC secretariat, an airline, another source, or a combination of these.

2.2.2 Evolution of the Characteristic

The draft is circulated and reviewed by the full committee, including the industry users and suppliers, for critique and alternative recommendations. Commentary is returned to the secretariat, where it is reviewed and consolidated into an updated draft; it is then returned to the subcommittee. When the revision is completed, the draft is again distributed to all participants. After a suitable time for review, a meeting is scheduled to permit discussion of areas of controversy or conflict. This iterative process is continued until acceptable documents are developed and approved. The steps in this process have been described informally[28] by the AEEC Chairman in a chart reproduced here as Figure 2-1.

After development, the document remains dynamic. Continuous feedback from users is circulated through AEEC to all interested parties, and supplements or reissues are prepared. The original 578 Characteristic, for example, was approved by the AEEC in October 1969. Supplement Number One was approved by the AEEC in April 1970; Characteristic 578-2 (containing Supplement Number Two) was issued in September 1971, and Characteristic 578-3 was issued in July 1974. This latter document (outlined in Appendix B-1) continues to receive updating changes. ARINC Characteristic 578 is currently used by the avionics industry for designing and producing new ILS receivers, and by the airlines to define their operational requirements for ILS avionics. It is likely that additional supplements will be processed and adopted by the AEEC before ILS is replaced by the future ICAO Standard Microwave Landing System (MLS) or Advanced Landing System (ALS).

2.2.3 Anti-Trust Factors

During the AEEC meetings, ARINC legal counsel is usually in attendance to assure that no decisions are made that could be construed to be price

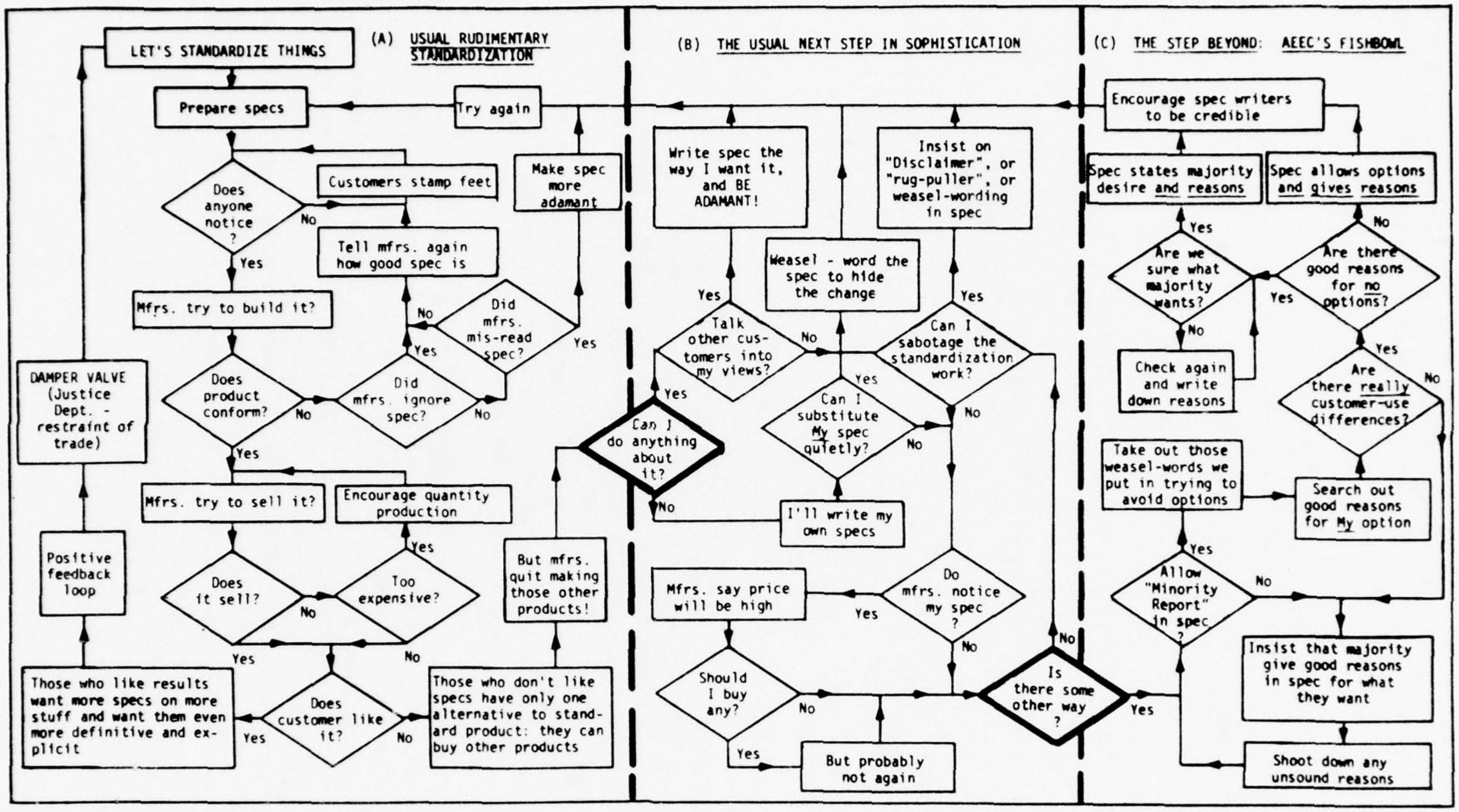

Figure 2-1. STEPS IN FORMING AN ARINC CHARACTERISTIC

fixing or restraint of trade. The exchange, otherwise, is as open as the manufacturer's protection of proprietary rights permits. Although specific price information is not permitted to be discussed, the economic impact of system features is discussed and the acceptability of associated technology explored.

2.2.4 Development Time

The usual timetable for producing a new Characteristic is about one year from the first AEEC meeting. The current DME (Distance Measuring Equipment) Characteristic is a typical example. The AEEC first agreed on the requirement for a new Characteristic in a January meeting. A subcommittee was formed immediately, and the first draft was ready in February. By October of the same year, four successive drafts had been prepared. In February of the following year -- 13 months after the first meeting -- the new ARINC Characteristic 568 was approved.

When the requirements and the technology are not well defined, the process takes longer. ARINC Characteristic 561, on Inertial Navigation Systems, is a good example. The first AEEC meeting took place in January, with the primary purposes of defining operational requirements and determining the "reasonable state of the art". The committee also reviewed all recent military experience with inertial systems. The first draft of the new Characteristic was not produced until the following January, one year after the initial meeting. By that time, the Boeing 747 aircraft was in production; both the airframe manufacturer and the airlines were anxious to obtain definitive information that could be used for finalizing the aircraft configuration. With these pressures increasing, the AEEC agreed on a conditional approval of the new Characteristic; it was complete except for certain digital interface provisions. The Airlines Communications Administrative Council (ALCAC) approved the new Inertial Navigation System Characteristic a year later in February, and it was published in June -- two and one-half years after the initial meeting. This timetable represents the opposite end of the spectrum for new, highly complex systems involving new technology and new operational requirements.

2.2.5 Design Benefit

The primary purpose of the exchange between user and supplier is to develop universally acceptable form-fit-function standards for the system under consideration. An important secondary benefit of the user/supplier participation in the committee activity is that the supplier develops a better understanding of the user's operational requirements beyond the specifically stated technical requirements. He is able to transform this understanding into a more realistic (cost-effective) design. This involves the trade-off between "gold plating", or excess capability beyond the operational need, and the price that will give him a competitive advantage.

2.3 CONTENT OF CHARACTERISTIC

2.3.1 Form, Fit, and Function

In addition to the basic operational performance parameters, the Characteristic contains the form-fit-function parameter definitions for the particular equipment under consideration to assure interchangeability of equipment produced by different manufacturers. These encompass equipment functional subdivision, package size, mounting, guidance regarding weight considerations (but not a specific weight requirement), cooling, equipment interconnection, and equipment interface with other avionics elements such as automatic flight controls, computers, and display devices. Characteristics can also include specific equipment performance/design requirements relating to the control and minimum performance requirements of the system elements, as well as automatic-test considerations. The example (Characteristic 578) presented in Section 2.2.2 is no exception; it requires the interchangeability of control units and receivers, regardless of the manufacturing source of the individual items. Signal outputs, which must interface with aircraft instruments, autopilots, couplers, and other aircraft wiring, are thoroughly specified to guarantee compatibility with these other devices.

The airline engineering representatives who produced the 578 Characteristic eliminated one unique item of interchangeability. The airlines usually demand "generation interchangeability" in addition to equipment interchangeability. The "generation interchangeability" was deleted from this new Characteristic in view of the new and more stringent requirements for driving autopilots and couplers for automatic approaches. It was feared that the inclusion of VOR functions (as in the older VOR/Localizer receivers) might tend to compromise the quality of the pure ILS functions in the new 578 equipment. This "separation of functions" has also been specified in the latest ARINC Characteristic for VOR Receivers (579). In each case, the airline operators and the avionics manufacturers agreed that the automatic approaches and landings probably could be better performed with dedicated ILS equipment than with add-ons to other equipment.

2.3.2 General Guidance in the Characteristic

ARINC Characteristics frequently provide general guidance for desired product development. For example, ARINC Characteristic 578, Airborne ILS Receiver, was developed during the late 1960s, when the aviation community recognized the need for ILS-coupled approaches. It describes receivers designed primarily for airline use. A quotation from 578 is self-explanatory: "The function of the ILS receiver is the reception of ILS Localizer and Glide Slope signals and the recovery therefrom of course-line deviation information for visual display to the pilot, and for use by an Automatic Flight Control System during automatically controlled approaches and landings."

Typically, the document further admonishes the manufacturers to produce "maintenance-free, high-performance radios rather than equipment of minimal weight and dimensions." Finally, removing any doubt of the desired

philosophy, 578 says "airline customers are interested primarily in the end result rather than the means employed to achieve it."

2.3.3 Appendixes

To consolidate the dominant technical considerations into one document, appendixes may be added to the Characteristic to present the Essential System Characteristics (ESC) of the International Civil Aviation Organization (ICAO) Annex 10, or the Technical Standard Orders (TSOs) for the equipment. Minimum Performance Standards are developed by the Radio Technical Commission for Aeronautics (RTCA) and, when adopted by the Federal Aviation Administration (FAA), become TSOs. In addition, a chronology and a bibliography may be included to permit a prospective supplier to review the evolution of the Characteristic and deduce the reasoning behind each iterative change. All supplements to the Characteristic are included in each reprint.

2.3.4 Supplemental References

As part of the equipment description in the Characteristic, references are made to the ICAO Annex, TSOs, ATA Specifications, and specific ARINC Characteristics, reports, or Military Specifications dealing with common aspects of avionics design. Table 2-2 lists typical references from ARINC Characteristic 578. Only three of the referenced documents are stringent regulatory items -- the ICAO Annex 10, which pertains to international telecommunications agreements; and the two FAA Technical Standard Orders that must be satisfied for certification of the equipment. The other references are more in the nature of guidance to manufacturers, although this guidance is quite persuasive since the equipment is not likely to be sold to the airlines unless the customer needs are fully satisfied.

As indicated in Appendix B-2, FAA ILS certification requires that Localizer and Glide Slope receivers satisfy the Minimum Performance Standards contained in RTCA Documents DO-131 and DO-132. Appendix B-3 identifies the parameters that are quantified as localizer performance standards in DO-131; Appendix B-4 identifies glide slope performance standards in DO-132.

These documents have received wide distribution in the avionics industry and have been used by all known current suppliers to guide their designs. This does not mean that all commercially available ILS receivers will meet performance standards presented in the RTCA documents. These standards are mandatory only for U.S. scheduled carriers. The higher-priced receivers used by the airlines (reflecting their strong commitment to maintenance of schedules with safety) may exceed most of the standards; the lower-priced receivers, such as those used in general aviation applications, reflect the less stringent demand for precise schedules. The latter equipments will meet the most important standards (such as channel capacity and frequency accuracy) but may not meet some of the other criteria (such as receiver sensitivity, dynamic range, and interference rejection). The degree to which a design complies with or exceeds the standards is some measure of equipment performance excellence.

Table 2-2. SUPPORTING DOCUMENTS REFERENCED IN CHARACTERISTIC 578

ARINC Specification 404	Air Transport Equipment Cases and Packing
ARINC Report 413	Guidance for Aircraft Electrical Power Utilization and Transient Protection
ARINC Report 414	General Guidance for Equipment and Installation Designers
RTCA DO-131	Minimum Performance Standards -- Airborne ILS Localizer Receiver
RTCA DO-132	Minimum Performance Standards -- Airborne ILS Glide Slope Receiver
ARINC Specification 410	Mark 2 Standard Frequency Selection System
MIL-STD-704	Aircraft Electrical Power Systems
RTCA DO-138	Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments
ICAO Annex 10	Aeronautical Telecommunications
TSO C34c	Technical Standard Order -- ILS Glide Slope Equipment
TSO C36c	Technical Standard Order -- ILS Localizer Equipment

2.3.5 Environmental Considerations

RTCA Document DO-138 (currently under revision by RTCA Committee SC-123) prescribes the environmental conditions and test procedures for airborne electronic and electrical equipment and instruments. Table 2-3 presents the temperature/altitude categories that may be applied to commercial equipment. The Technical Standard Orders do not ordinarily require any specific category from DO-138; however, they do require the equipment nameplate to carry the proper inscriptions defining the design limits or test limits employed in the qualification of that equipment. The buyer can consult the nameplate and determine the level of environmental qualification for which a particular box has been tested.

2.4 PURCHASE DOCUMENTATION

2.4.1 Procurement Documentation

The AEEC-developed Characteristic is applied individually by the airlines. While the detail differs from one procurement to the next (depending

philosophy, 578 says "airline customers are interested primarily in the end result rather than the means employed to achieve it."

2.3.3 Appendixes

To consolidate the dominant technical considerations into one document, appendixes may be added to the Characteristic to present the Essential System Characteristics (ESC) of the International Civil Aviation Organization (ICAO) Annex 10, or the Technical Standard Orders (TSOs) for the equipment. Minimum Performance Standards are developed by the Radio Technical Commission for Aeronautics (RTCA) and, when adopted by the Federal Aviation Administration (FAA), become TSOs. In addition, a chronology and a bibliography may be included to permit a prospective supplier to review the evolution of the Characteristic and deduce the reasoning behind each iterative change. All supplements to the Characteristic are included in each reprint.

2.3.4 Supplemental References

As part of the equipment description in the Characteristic, references are made to the ICAO Annex, TSOs, ATA Specifications, and specific ARINC Characteristics, reports, or Military Specifications dealing with common aspects of avionics design. Table 2-2 lists typical references from ARINC Characteristic 578. Only three of the referenced documents are stringent regulatory items -- the ICAO Annex 10, which pertains to international telecommunications agreements; and the two FAA Technical Standard Orders that must be satisfied for certification of the equipment. The other references are more in the nature of guidance to manufacturers, although this guidance is quite persuasive since the equipment is not likely to be sold to the airlines unless the customer needs are fully satisfied.

As indicated in Appendix B-2, FAA ILS certification requires that Localizer and Glide Slope receivers satisfy the Minimum Performance Standards contained in RTCA Documents DO-131 and DO-132. Appendix B-3 identifies the parameters that are quantified as localizer performance standards in DO-131; Appendix B-4 identifies glide slope performance standards in DO-132.

These documents have received wide distribution in the avionics industry and have been used by all known current suppliers to guide their designs. This does not mean that all commercially available ILS receivers will meet performance standards presented in the RTCA documents. These standards are mandatory only for U.S. scheduled carriers. The higher-priced receivers used by the airlines (reflecting their strong commitment to maintenance of schedules with safety) may exceed most of the standards; the lower-priced receivers, such as those used in general aviation applications, reflect the less stringent demand for precise schedules. The latter equipments will meet the most important standards (such as channel capacity and frequency accuracy) but may not meet some of the other criteria (such as receiver sensitivity, dynamic range, and interference rejection). The degree to which a design complies with or exceeds the standards is some measure of equipment performance excellence.

Table 2-2. SUPPORTING DOCUMENTS REFERENCED IN CHARACTERISTIC 578

ARINC Specification 404	Air Transport Equipment Cases and Packing
ARINC Report 413	Guidance for Aircraft Electrical Power Utilization and Transient Protection
ARINC Report 414	General Guidance for Equipment and Installation Designers
RTCA DO-131	Minimum Performance Standards -- Airborne ILS Localizer Receiver
RTCA DO-132	Minimum Performance Standards -- Airborne ILS Glide Slope Receiver
ARINC Specification 410	Mark 2 Standard Frequency Selection System
MIL-STD-704	Aircraft Electrical Power Systems
RTCA DO-138	Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments
ICAO Annex 10	Aeronautical Telecommunications
TSO C34c	Technical Standard Order -- ILS Glide Slope Equipment
TSO C36c	Technical Standard Order -- ILS Localizer Equipment

2.3.5 Environmental Considerations

RTCA Document DO-138 (currently under revision by RTCA Committee SC-123) prescribes the environmental conditions and test procedures for airborne electronic and electrical equipment and instruments. Table 2-3 presents the temperature/altitude categories that may be applied to commercial equipment. The Technical Standard Orders do not ordinarily require any specific category from DO-138; however, they do require the equipment nameplate to carry the proper inscriptions defining the design limits or test limits employed in the qualification of that equipment. The buyer can consult the nameplate and determine the level of environmental qualification for which a particular box has been tested.

2.4 PURCHASE DOCUMENTATION

2.4.1 Procurement Documentation

The AEEC-developed Characteristic is applied individually by the airlines. While the detail differs from one procurement to the next (depending

Table 2-3. ALTITUDE AND TEMPERATURE CRITERIA FOR RTCA EQUIPMENT CATEGORIES IN FIVE TYPES OF ENVIRONMENT

Condition	Unpressurized Aircraft Environment			Pressurized Aircraft Environment		Severe Aircraft Environment		SST		Engine Compartment Components			
	A	B	C	D	G	H	J	K	L	M	N	P	Q
Maximum Operating Altitude (Thousands of feet)	45	30	20	15*	15*	50	35	80	65	35	50	80	65
Test Altitude (Thousands of feet)	55	35	25	20*	20*	60	40	90	75	40	60	90	75
Decompression-Test Altitude (Thousands of feet)	--	--	--	40	40	--	--	--	--	--	--	--	--
Overpressure Test (Thousands of feet)	--	--	--	-15	-15	--	--	--	--	--	--	--	--
Non-Operating Temperature - Low	-62	-50	-50	-50	-54	-85	-65	-65	-65	-65	-65	-65	-65
(Degrees Centigrade) - High	+71	+71	+71	+71	+71	+71	+71	+274	+150	+100	+150	+538	+250
Short-Time Operating High Temperature (Degrees Centigrade)	+71	+71	+71	+60	+71	+71	+71	+274	+150	+100	+150	+538	+250
Operating Temperature - Low	-54	-46	-40	-15	-15	-85	-65	-54	-54	0	-54	-54	-54
(Degrees Centigrade) - High	+55	+55	+55	+55	+71	+71	+71	+274	+132	+100	+150	+538	+250

*The maximum operating altitude and test altitude of Category D and G equipment represent atmospheres established by pressurization.

on quantity and other factors), and from one airline to another, the general process is the same. The airline technical and contracts/ procurement personnel develop the total procurement documentation. This documentation may invoke the Characteristics only by reference or may not mention them at all; but it sets forth in detail the airline requirements for support, reliability, warranty, quantity, and other desired features. It is then used as the basis for negotiation with the supplier.

2.4.2 Supplier Selection

The supplier is selected in a simple manner, since the equipment has been manufactured to ARINC Characteristics and the aircraft wired for the equipment. Satisfaction with past performance is a major selection factor. A given procurement may be influenced by other considerations from the supplier; examples are reductions in the cost of modifications to other equipment that the supplier has furnished to the airline, or "trade-in" allowance on a competitor's equipment that is being replaced. While use of trade-ins as negotiation points is not specifically recommended, the Air Force may wish to explore this possibility for its cost advantages.

The availability of several interchangeable, competing designs establishes the climate in which a cost-effective selection can be made. In each instance, however, it is always clear that the airline expects satisfactory service from the new equipment or the next purchase will be another supplier's product.

Each major vendor attempts to establish a favored position with a particular airline. The personal relationship between the vendor and an airlines avionics-acquisition team serve to encourage the "favored supplier" climate. Personal relationships are only a part of the favored position, however. Demonstrated performance as an indication of supplier commitment to the airline's requirement is the principal factor. Occasionally, an airline will try a manufacturing competitor's avionics equipment (perhaps without purchase but on a trial-performance basis) to compare it with previously purchased products and to consider it for future acquisition.

The "favored position" makes it more difficult for a new vendor to establish himself in the market; it requires that the vendor prove himself and his product. This must be accomplished by producing an equipment with outstanding capability or cost benefits and by demonstrating a commitment to support the airline operation. Assuring the availability of the function the equipment performs, rather than providing simply a piece of hardware, becomes the primary factor for the supplier and discourages a casual entry into the market.

2.4.3 Support Considerations

Each airline negotiates contract items that reflect its particular operations and maintenance philosophy. Level of spares, documentation for maintenance, training of maintenance personnel, and other factors vary significantly between airlines. Most of the major carriers, however, prefer to have their own maintenance organizations since equipment may be kept in the operating inventory for 20 years. The acquisition of new equipment usually involves a warranty, with reliability demonstration to

permit equipment anomalies to be reconciled, a stable reliability characteristic to be demonstrated, and a final equipment configuration to be established. From this experience, accurate spares requirements can be established, maintenance personnel can gain experience with the system, documentation needs can be identified, and decisions can be made to modify existing test equipment or buy new equipment. The warranty period can cover one year to five years, depending on the maturity of the equipment design, the decision to support or not support organically, and other factors.

2.5 MARKET ASPECTS

2.5.1 Market Continuity

In the airline avionics market, continuing procurements occur as new aircraft are acquired, regulations relating to avionics change, or technological advances offer cost benefits to airline operation that are attractive enough to dictate new equipment acquisition. (Examples of these circumstances are the impetus for 25-kHz channel spacing in the VHF spectrum, which will have a significant impact on much of the NAV/COM avionics in use; and the introduction of the inertial navigation systems, which permitted the airlines to reduce the aircraft crew by one member on certain flights.) A relatively continuous and predictable market prevails as a result.

2.5.2 Manufacturer Motivation

A significant benefit of the airline avionics continuing market for standard form-fit-function equipment is the opportunity it presents to the various manufacturers: loss of an award from one airline does not deny a manufacturer access to the rest of the market. He may attempt to sell his product to another airline, or to the same airline on a subsequent procurement, by offering features or price that he believes will provide a competitive advantage. As a result, there is constant encouragement to enhance product performance within the bounds of operational requirements and to reduce cost with a view to potential sales during the next procurement.

Individual orders for commercial avionics deliveries, seldom more than 100 units, provide the uniform and predictable avionics market during a given time interval. Manufacturers can therefore project a market segment they can expect to capture with the commitment of certain resources. Thus production capability can be geared to meet the market, and relatively stable equipment cost estimates can be made. Use of risk capital in the preparation of an equipment can then be prudently justified.

Since most of the research and development associated with new avionics technology is funded by the Government, the manufacturers can direct their attention and resources to adapting this technology to commercial application. Little of the commercial aviation equipment represents an attempt

to extend the electronic engineering "state of the art". Vendors who manufacture for the air transport industry concentrate on the interchangeability, reliability, and performance of their equipment; "state of the art" has very little selling power in the airline community unless it offers substantial cost benefits.

CHAPTER THREE

A COMPARISON OF COMMERCIAL AIRLINE AND MILITARY PROCUREMENT PROCESSES

3.1 INTRODUCTION

To identify elements of the commercial avionics procurement process that might be considered for adaptation to the military process, the two processes are compared here and similarities and differences are examined. It is important that the reader appreciate that our major concern is with the *processes* by which commercial and military procurements are made. The commercial Characteristic and the Military Specification represent only elements of the processes (see Figure 3-1). While they are admittedly important elements, the differences in the two documents are reflections of basic philosophical differences in the overall procurement approaches. As noted in Chapter Two, the commercial process encourages and depends on sustained competition throughout the life of an equipment. In the military procurement, there is generally no multiplicity of suppliers for a particu-

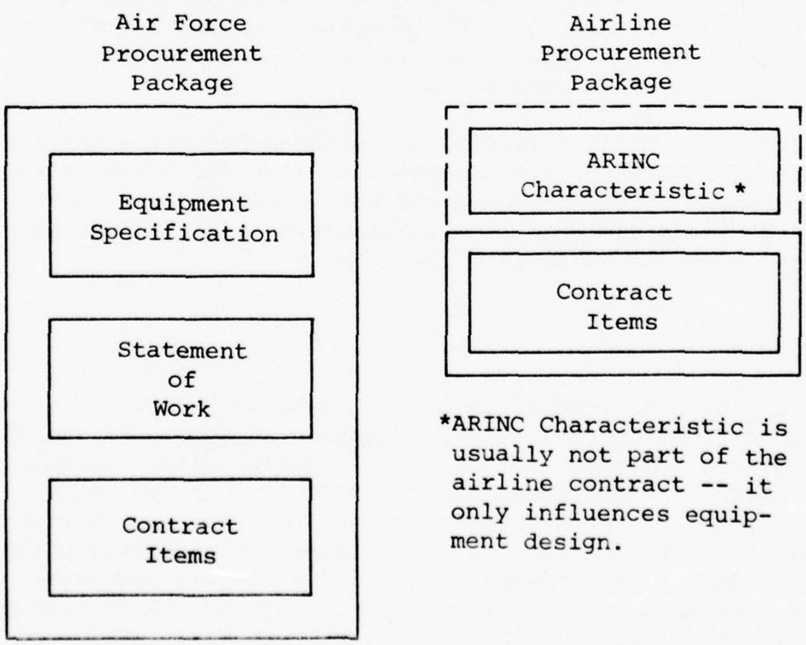

Figure 3-1. SIMPLIFIED COMPARISON OF AIR FORCE AND AIRLINE PROCUREMENT PACKAGES

lar system. It is understandable, then, that the procurement processes and documents are significantly affected by the differences in approaches.

With this recognition of the basic philosophical differences in the two processes, we can concentrate on the resultant differences in the controlling documents. Specifically, we will compare the Characteristic-type document with the Military Specification in terms of development, content, and application.

3.2 ASSUMPTIONS AND CONSTRAINTS

For purposes of this comparison, two conditions are imposed to limit the effort to the time and funds available:

- Only elements of the military process that are applicable to the ALS procurement are considered.
- It is assumed that the equipment will make use of long-term warranty and contractor support as opposed to Air Force organic support. As noted above, this assumption was necessary to permit the timely completion of the effort. It should not be concluded from this work that contractor support is essential to military use of commercial procurement practices. The use of organic maintenance was simply not treated; thus conclusions concerning such support cannot be drawn from this study.

This latter assumption, however, may not be so limiting as might be expected. The contractor-maintenance approach can be altered even following initial procurement. If such an option is anticipated, however, arrangements should be made to ensure that the contractor will be able to provide any required documentation.

The topic of organic versus contractor support involves extensive trade-offs,[24] for which data are currently being developed through several pilot programs. By the time the ALS specifications are to be applied to a procurement, it is expected that substantive data will permit determination of the most cost-effective approach.

3.3 APPROACH

The approach to comparison of the elements of the two procurement processes involved several steps. Examples of documents for specific equipments were examined and compared. Specifically, the Characteristic for the commercial Instrument Landing System (ILS) was compared with the military AN/ARN-XXX TACAN Specification. The ARN-XXX was chosen instead of the military ILS because the latter does not represent a typical military procurement. The ARN-XXX represents a current procurement with extensive invocation of supporting specifications and is comparable, in terms of function and technology, with ILS and ALS. While the AN/ARN-XXX document is a combined development and production specification, it is illustrative of the content of the typical avionics specification.

As a part of the review of the two procurement processes, ARINC Research interviewed numerous personnel and examined various applicable regulations and guidance documents, as well as typical provisions contained in Military Specifications, to determine whether this classical, stringent documentation would be required if the commercial process were applied to the ALS program.

With the scope of the investigation thus defined, the steps by which Military Specifications and ARINC Characteristics are developed and the content of the resulting documents are compared in Section 3.4. In Section 3.5, the effects of the documents on purchasing practices are considered.

3.4 COMPARISON OF THE DEVELOPMENT AND CONTENT OF MILITARY SPECIFICATIONS AND ARINC CHARACTERISTICS

In this section, we will compare the procedures by which Military Specifications and commercial characteristics are developed (Section 3.4.1). In Section 3.4.2, we will compare the content of the two resulting documents.

3.4.1 Development of the Documents

3.4.1.1 Initial Activities

In both the military and commercial situations, higher-level management authorizes the development of a specification on the basis of a justified need. In the case of the ALS system, the need is to permit aircraft to operate into appropriately instrumented landing sites. The System Project Office (SPO) and the airline engineering organizations are assigned responsibility for preparing the military and commercial documents, respectively.

The SPO assigns a project engineer or project manager to initiate specification development. To prepare this document, he may employ a team of selected Air Force personnel, assign the task to an Air Force laboratory that possesses the requisite skills, contract with a consulting organization, or use some combination of the three.

In the commercial situations, the AEEC airline representatives direct the committee to prepare the appropriate Characteristic. A subcommittee chairman who is particularly knowledgeable in the specific area is named, and the subcommittee is formed to write the document. The subcommittee is composed of interested airline and industry participants who are technically expert in the subject area.

3.4.1.2 Basic Guidance and Methods

Preparation of the Military Specification is heavily influenced by the requirements and conventions of MIL-STD-490, Military Standard Specification Practices. Each requirement element in MIL-STD-490 must be addressed. While it is not necessary for the project manager to emphasize all items equally, if he does not, he must be prepared to defend why he is de-emphasizing

some item before any of a number of reviewing specialists. While this conventional emphasis can have significant cost implications, the Air Force nevertheless generally adheres to the conventional Military Specification development process.

In development of physical and operational performance specifications, frequently the requirements are offered only by a single user, although in some cases the development of the specification takes advantage of information from other using-command requirements and from manufacturers on an individual basis. However, because the Military Specification conventionally includes considerable internal-design detail, manufacturer-contributed information, if used, can bias the subsequent procurement in favor of the contributor's technology and compromise the competitive aspect of the purchase. The Air Force, therefore, is particularly careful about accepting a particular manufacturer's recommendations concerning a new equipment specification. In addition, unless an individual manufacturer's contribution is thoroughly examined in relation to the alternatives, potential applications, and costs, an approach may be adopted that represents something less than the best alternative; and this becomes "frozen" into the design. These and other factors work against interchangeability; and the buyer becomes a captive of one manufacturer's unique system and is subject to subsequent additional costs for modifications to alter undesired parameters identified after the award.

A significant difference in the commercial process is that the airline Characteristics are developed in open exchange with the avionics and airframe manufacturers, encouraging thorough examination of the various considerations. Guidance is received from the committee members (users), emphasizing each member organization's peculiar requirements. The need for interchangeability among manufacturers' products is stressed, and the competitive basis for future procurements is established. This exchange emphasizes the technical application of the equipment. Special considerations such as reliability, repair, training, and warranty are handled by the individual airlines for each procurement.

The "open forum" approach may be employed by the Air Force. Comments on committee operations and conflict of interest that should be considered are included in Chapter Four, Sections 4.3.1.1 and 4.3.1.3, respectively.

All technical contributions are finally circulated among the full membership of the AEEC for review and comment before the Characteristic takes final form, further assuring broad technical acceptability. The military also conducts a review process. The emphasis, however, is generally on assuring that all requirements imposed by regulations and references will be met. After initial preparation, the new draft specification must undergo an extensive coordination cycle to assure that it properly reflects all the requirements imposed by the regulations and references. Unfortunately, many of these requirements are not directly applicable to the basic operational characteristics of the equipment but address other ancillary considerations. Because of this emphasis on the other items, a broad assessment from many conflicting vantage points (as occurs in the open forum) may not be accomplished. Further, many of the persons who review the new document

have a tendency to add more restrictive elements -- elements that were relevant to a previous procurement, that prescribe another function, or that otherwise increase the complexity of the document without a strong incentive to reduce cost.[12]

If the specification is to be used by more than one command or more than one military service, this cycle of amendments and changes is even more complex. By the time the new specification is ready to be published, it often contains numerous regulatory references, a set of difficult performance requirements that may be unduly influenced by a few extreme applications, a stringent test program not necessarily representative of the end-use environment, and a formidable list of test plans and reports that must be prepared by the hardware contractor -- all intended to assure proper field performance.

The airlines also require that the supplier provide some administrative items. In general, however, the airlines determine product acceptability on the basis of in-service performance. This performance reflects requirements for such items as documentation, spares, and test requirements. The supplier, then, is made responsible for in-service performance.

The concept of in-service satisfaction may also be adopted by the Air Force. Early, rigorous field testing, involving perhaps a "lead the fleet" operation, coupled with an effective warranty plan (see Section 4.3.2.3), can provide the kind of product assurance achieved by the airlines.

3.4.1.3 Time Required for Development and Coordination

The development of the draft Military Specification can be very rapid. However, the final coordination of the document is usually time-consuming. The process is further lengthened by the numerous changes and amendments that must be incorporated to satisfy individual coordinating activities.

The development of the ARINC Characteristic, on the other hand, is usually a time-consuming process. However, the coordination is effectively included in the development process. The final approval cycle of the ARINC Characteristic consists only of concurrence by the Airlines Electronic Engineering Committee. The document is then published by ARINC.

Actually, because the ARINC Characteristic develops rather slowly, the manufacturers often do much of their product development during the process, so that one or more equipment manufacturers usually have designed and demonstrated their boxes before the Characteristic is published. Government certification is not usually a time-consuming process, and manufacturers can accept orders at about the same time the Characteristic is completed. This is, of course, considered by the suppliers to be an effective marketing approach. The users have described their requirements, and the suppliers proffer actual equipments to meet the requirements. There is an obvious advantage to having a suitable equipment for sale before the competitors do. There are few examples of this kind of timely response and competitive, risk-capital development in the military avionics environment.

If an Air Force specification-development committee of responsible representatives from all interested activities is formed, the approval cycle should be less time-consuming. Managers will be aware of the specification content while the development is progressing and can influence the content through their representatives. When completed, the document should contain no surprises and should therefore be subject to expeditious approval.

3.4.2 Comparison of the Resulting Documents

Because of the basic philosophical differences between the military and commercial procurement approaches, there are some significant differences in the specification documents.[12] In essence, the military depends on the specification to assure that all equipment characteristics considered essential to proper field performance will be met. The supplier then develops an equipment to meet the *specification*. If the resultant equipment does meet the specification requirements, the supplier has fulfilled his responsibility, regardless of whether the specification adequately reflects the end-use requirements. Since the procuring activity recognizes this situation, major attention is directed to addressing in the specification every factor that might influence field performance of the equipment.

The airlines, on the other hand, judge the acceptability of the equipment on the basis of in-service performance. In essence, the supplier is made responsible for meeting an *end-use requirement* rather than for fulfilling the specification requirements. This, of course, is possible because alternate equipment sources are available. If an equipment is unsatisfactory in actual use, the manufacturer may be required to make no-cost corrections. In the case of reliability problems, he might be required to furnish (at no additional cost) additional pipe-line items to compensate for the impact of failure. In some cases, the user might be willing to accept the deficient performance on the basis of a price adjustment. If a mutually satisfactory solution cannot be agreed upon, the supplier may have to withdraw his entire submission.

Not surprisingly, then, this basic difference in approaches is reflected in the length, coverage, and amount of detail in the two document types. In the following paragraphs, we will indicate the effects of these differing philosophies on the documents by comparing the content of military specifications with the content of ARINC Characteristics. To facilitate the comparison, we will address the six standard sections of Military Specifications and compare the content of each with the coverage provided by the ARINC Characteristic.

3.4.2.1 Section 1: Scope

The "scope" section of the Military Specification indicates the content of the specification and identifies the equipment of interest. This function is similarly accomplished in the introductory section of a Characteristic.

3.4.2.2 Section 2: Applicable Documents

In the "Applicable Documents" section of the Military Specification, the documents referred to in the specification are tabulated. In general, a Military Specification calls out many more references than does a Characteristic.

A striking illustration of this point was provided in a 1973 report[13] prepared by the Defense Science Board. In their report, the Board showed a "typical example" of the content and application of specifications and standards in a Military Specification and its commercial counterpart. Figure 3-2, taken from their report, compares the references from the AN/ARC-XXX specification with those called out in the Characteristic for the VHF communications transceiver. The Board's comments are quoted in the following paragraphs:

"VHF Radio, ARINC Characteristic:

Basically, ten documents cover this procurement. Examinations of these ten documents will show that the hardware definition is a functional specification only, with no attempt made to define methods, processes, materials, or components. In other words, this description relates only to form, fit, and function. ('Function' will define environmental and safety-of-flight characteristics.)

"UHF Radio, DoD Specification:

It is obvious that the typical Military Specification goes far beyond a mere definition of form, fit, and function. In addition to design details, the Military Specifications also define processes, materials, components, quality procedures, and other similar requirements. For instance, there are:

4 specifications and standards on soldering

26 specifications and standards on fastener hardware

10 specifications and standards on structural welding

21 specifications and standards on adhesives

"The first three specifications and standards called out by MIL-E-5400 require 13 pages just to list by title.

"In the case of the commercial contract, enforcement of all documentation depends upon the guidelines set by the users. Each manufacturer complies to the degree he believes necessary to sell his product. By virtue of their procurement activity, the users of the equipment have final approval (enforcement) of what is procured. They directly procure their equipment from the manufacturer of their choice, and they only have to buy what they actually need in the way of performance -- the product which most clearly meets their requirements.

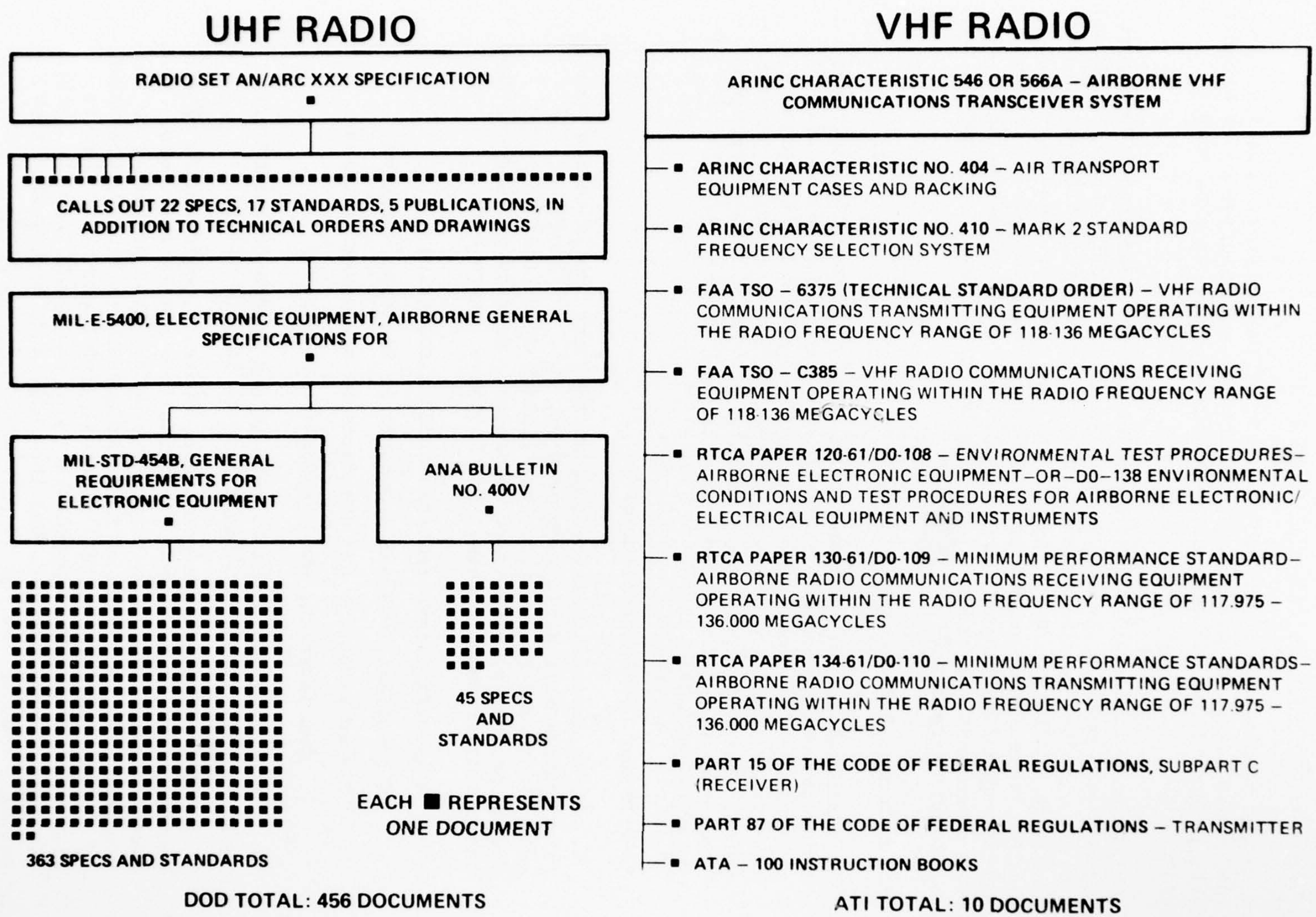

Figure 3-2. COMPARATIVE SPECIFICATIONS AND STANDARDS REQUIREMENTS FOR EQUIVALENT DOD AND AIR TRANSPORT INDUSTRY EQUIPMENT

"When DoD procurement agencies select commercial equipment for their use on a contract, they add to the end-item cost considerably by listing the commercial part number, assigning new Federal Stock numbers, and then reverting to the commercial part number before they can obtain the item through the DoD procurement system.

"DoD applies a large hierarchy of specifications and standards that are often not strictly applicable to the product -- but they *are* applied and enforced."

3.4.2.3 Section 3: Requirements

The "Requirements" section of a military specification is a substantial portion of the document. The intent of the section is indicated by the following excerpt from MIL-STD-490:

"4.3 Section 3 - REQUIREMENTS. The essential requirements and descriptions that apply to performance, design, reliability, personnel subsystems, etc. of the item, material or process covered by the specification shall be stated in this section. These requirements and descriptions shall define, as applicable, the character or quality of the materials, formula, design, construction, performance, reliability, transportability, and product characteristics, chemical, electrical, and physical requirements, dimensions, weight, color, nameplates, product marking, workmanship, etc. This section is intended to indicate, as definitively as practicable, the minimum requirements that an item, material or process must meet to be acceptable. The Requirements section shall be so written that compliance with all requirements will assure the suitability of the item, material or process for its intended purpose, and non-compliance with any requirement will indicate unsuitability for the intended purpose. Only those requirements shall be specified that are necessary and practicably attainable."

In some areas, the Military Specification and the ARINC Characteristic are similar. In other areas, the emphasis is considerably different. In the matter of performance, for example, both documents describe the same general requirements. Table 3-1 was prepared to aid in this comparison. It displays the performance characteristics called out in the Military Specification for the ARN-XXX (but omitting the DME portions to make the two equipments more comparable) and in ARINC Characteristic 578 for the Airborne ILS Receiver. The table shows that both address the same basic performance parameters and environmental conditions.

In Table 3-2, the requirements of the two documents dealing with physical characteristics of the two equipments are shown. While both dictate conditions relating to form and fit, it is significant that the ARINC Characteristic tabulates these factors under the heading of "Interchangeability", which is the major reason for their specification.

Table 3-1. A COMPARISON OF MILITARY AND CIVIL EQUIPMENT SPECIFICATION GUIDELINES: PERFORMANCE FEATURES

Military Specification DCTE 72-1 Airborne ARN-XXX TACAN Navigation Set	ARINC Characteristic 578-2 Airborne ILS Receiver
Environmental Tolerance Environmental-Condition Definition Vibration Shock Temperature/Altitude Thermal Control Altitude Humidity Rain Exposure Explosion Sand and Dust Fungus Crash Safety	Environmental Tolerance Environmental-Condition Definition Environmental Categorization Temperature/Altitude Humidity Shock Vibration Temperature Variation Voltage/Frequency Variation Low Voltage Conducted Voltage Transients Conducted Audio Frequency and Susceptibility Explosion
Receiver Performance Signal Processing/Decoding Selectivity Sensitivity Co-Channel Detection Automatic Gain Control Automatic Overload Control Antenna Selection Input/Output Suppression Self-Test Function Frequency Selection Distance/Bearing Data Transmission Format	Receiver Performance (Glide Slope and Localizer) Frequency Range of Operation Frequency Channeling Frequency-Selection System Sensitivity in Aural Reception (Localizer Only) Sensitivity in ILS Signal Reception Selectivity Spurious Response Cross Modulation Adjacent Channel Performance (Localizer Only) Performance in Presence of VHF Communications Transmissions (Localizer Only) Automatic Gain Control Densensitization and Interference Rejection Audio Output (Localizer Only)
Audio Identification Function	Localizer Receiver Only Voice/Identification Function
Bearing Tracking Rate Accuracy Signal-Acquisition Time Memory Signal Acquisition vs. External Phase Shift Signal Memory	Glide Slope and Localizer Equipment Centering Accuracy Deflection AGC Characteristic Deflection Balance Deflection Stability RF Sensitivity Voltage Standing Wave Ratio (Receiver and Antenna) RF Energy Emission Selectivity Receiver Performance with Two Carriers Spurious Response Antenna Efficiency Operation of Two Receivers from Same Antenna
Control Unit Functional Description Channel Selector Volume Control Panel Lighting Retrofit Adaptor Function Analog Outputs Analog Output Connections	ILS Equipment Driver Automatic-Flight-Control System Outputs High-Level Instrumentation Outputs Low-Level Instrumentation Outputs Deviation-Output Polarity Deviation-Output Interface Standards Localizer Course-Deviation-Output Linearity Glide-Slope Course-Deviation-Output Linearity Localizer Course-Centering Stability Glide-Slope Course-Centering Stability Automatic-Flight-Control System Warning Signals High-Level Instrument Warnings Low-Level Instrument Warnings Glide-Slope Deviation Bar and Flag Raising
Self-Test Function	ILS Monitoring Requirements Input-Signal Monitoring Localizer-Failure Monitoring Glide-Slope-Failure Monitoring Monitor Integrity Monitor Sensitivity
Response to Input-Power Variation Thermal Dissipation Electromagnetic Radiation	Deviation and Instrument Warning Signal Switching Audio Signal Switching

Table 3-2. A COMPARISON OF MILITARY AND CIVIL EQUIPMENT SPECIFICATION GUIDELINES: PHYSICAL ATTRIBUTES

Military Specification DCTE 72-1 Airborne ARN-XXX TACAN Navigation Set	ARINC Characteristic 578-2 Airborne ILS Receiver
Receiver/Transmitter Weight Form Factor Connectors, Input/Output Modularity Front Panel Configuration Suppression Connectors AGE Connectors Control Unit Weight Form Factor Modularity Mechanical Design Unit Interchangeability Product Marking Workmanship Human Engineering Overload Protection Anti-Jamming Materials, Processes, and Parts Moisture and Fungus Resistance Parts Selection Nonstandard Parts Approval Finish and Color Electrical Connectors Microcircuit Devices Corrosion Quartz, Crystal Units Elapsed Time Indicators Motors Wiring Cables, Waveguides, Cable Assemblies Electromagnetic Radiation Equipment Spectrum Signature Data Antenna Conducted Spurious Electromagnetic Interference Control	Interchangeability Standards Receiver Form Connectors Hold Downs, Extractors Projections Cooling Interface Wiring Control Panel Configuration Connectors Frequency Selection Method On/Off Control Integral Lighting Interface Wiring Power Circuitry Primary Power Input Power Control Circuitry Common Ground Restrictions AC Common Hold Limitations Antenna Frequency Requirements Radiation Pattern Considerations Transmission Line Considerations Interwiring Automatic Test Equipment Connections Unit Identification Pin Allocation

In relation to interchangeability, it is noted that one aspect of the ARN-XXX specification represents a desirable change in requirements. It specifies that the new TACAN must be compatible with the AN/ARN-21 wiring already installed in aircraft, thus eliminating the need for an aircraft modification to accept the new black box when it becomes available. This is a part of the so-called form-fit-function approach that has been standard in airline equipment for many years, but it is unusual in military requirements and could undoubtedly have been used to advantage in past procurements. One important aspect was not included in the ARN-XXX requirement. There was no stipulation that wire-for-wire signal/level compatibility be maintained or that all equipment elements be interchangeable between manufacturers' systems. As a result, individual system elements cannot be replaced. In the event a replacement is required, either the same manufacturer's item must be used or the entire system must be replaced.

Two additional observations concerning requirements seem appropriate. The Military Specification includes a section on Materials, Processes, and Parts. No equivalent is contained in the Characteristic, indicative of the commercial philosophy of stating "what" is desired as opposed to "how" it should be provided. Further, the Military Specification "Requirements" section is the basis for acceptance or rejection of the item -- not end-use performance.

Several additional requirements imposed by the Air Force and the airlines are tabulated in Table 3-3. As indicated, these requirements are generally not included in the Characteristic but are reflected in the procurement (contract) document. There are excellent reasons for this practice, primarily in the interest of promoting competition and flexibility. These items are customarily handled in this manner so that varying user needs may be accommodated in each different contract in a cost-effective manner and without the need for committee action if a contract item change is required. The flexibility also permits accommodation of product technical growth and lessons learned in such areas as reliability, maintenance, logistics, and training without compromising the interchangeability for the user. Since the Air Force constitutes a single procurement activity, the flexibility provided by separation of these requirements is of less concern.

Particular attention is directed to the requirements for documentation. The AN/ARN-XXX procurement is somewhat unique in that some added documentation is involved because of the imposition of warranty conditions. The provision for AFLC responsibilities in the procurement also results in some extra reporting requirements. Nevertheless, the AN/ARN-XXX specification provides a useful model for comparison with the documentation requirements in the commercial Characteristic. Table 3-4 lists the DD Form 1423 data requirements included in the AN/ARN-XXX specification and the requirements included in a similar airline procurement. The appreciably greater requirements of the Military Specification are apparent, and the cost implications to the supplier and the buyer in generating and using the data are significant.

Table 3-3. A COMPARISON OF MILITARY AND CIVIL EQUIPMENT SPECIFICATION GUIDELINES: ANCILLARY ITEMS

Military Specification DCTE 72-1 Airborne ARN-XXX TACAN Navigation Set	ARINC Characteristic 578-2 Airborne ILS Receiver
Reliability Characteristics	
System MTBF Requirements Component MTBF Requirements Life Expectancies Definitions	Not part of a characteristic; treated by contract item
Maintainability Characteristics	
Operational Stability Scheduled Maintenance Requirements Equipment Checkout, Fault Isolation, and Repair Modularity Requirements Definitions	Part of ARINC equipment characteristics Covered by other ARINC Characteristics or ATA specifications
Logistics Design Considerations	
Maintenance Requirements Supply Requirements Facilities and Facility Equipment Requirements	Not part of a characteristic; treated by ATA specifications and contract item
Personnel and Training	
Personnel Requirements Operational Maintenance Training Requirements	Not part of a characteristic; treated by contract item
Transportability Characteristics	
Transportation Modes Employment Deployment Logistics Support Storage	Not part of a characteristic; treated by contract and ATA specifications
Installation Orientation/Vibration Isolation	Treated by ARINC Characteristic
Documentation	
Contract Data Requirements	Not part of a characteristic; treated by contract and ATA specifications

3.4.2.4 Section 4: Quality-Assurance Provisions

Quality-assurance provisions in the USAF and airline equipment-acquisition processes differ significantly, as represented in Table 3-5. While the airlines do pursue quality-assurance programs, albeit in an informal manner, the market environment provides the primary incentive to manufacturers for product performance. The military, on the other hand, strives to obtain product performance through very thorough test and evaluation programs during development and prior to acceptance. The basic military approach is to perform all examinations and tests necessary to ascertain that all requirements have been met.

Table 3-4. DOCUMENTATION COMPARISON	
Contract Data Requirements -- AN/APN-XXX Procurement	Typical Airline Procurement Data Requirements*
Monthly Reports Program Schedule Report Production Analysis Report Production Progress Report Configuration Management Accounting Report Cost Performance Report Quarterly Reports Data Accession List/Internal Data Report Contract Funds Status Report Reliability and Maintainability Allocations, Assessments, and Analysis Reliability and Maintainability Data Reporting, and Feedback Failure Summary Reliability/Maintainability Program Status Report One-Time Reports Procurement Method Information Engineering Data for Initial Logistic Support (Category D) Engineering Data (Category H) Engineering Data (Category I) Engineering Data (Non-Government Design) Contract Cost Data Summary Progress Curve Report Preservation and Packaging Report Master Material Support Record Decalcomanias and Other Markings Technical Orders Bulk Items List Delinquency Delivery Report for Spare Parts Spare/Repair Parts/AGE Delivery Schedule Numerical Parts List Preliminary Group Assembly Parts List Post Source Coding Conference Production List Soft Consumable Items List Provisioning Screening Data Aerospace Ground Equipment Plan Configuration Item Development Specifications Configuration Item Product Fabrication Specifications Non-Standard/Non-Preferred Electronic Parts Data Parts Control and Standardization Plan Engineering Drawings for Design Review, Audits, and Evaluation Contract Cost Data Summary Training Support Data Technical Order Publication Plan Technical Orders (Manuscript Copy) Preliminary Technical Orders Validation Record for Technical Orders Electromagnetic Compatibility Plan Reliability/Maintainability Program Plan Reliability/Maintainability Demonstration Plan Optimum Repair Level Analysis Reliability/Maintainability Assessment Test System/Design Trade Study Reports Acceptance Test Procedures Identification List of Standard/Modified Hand Tools Electromagnetic Compatibility Test Plan Equipment Test Plan (Non-System) General Test Plan/Procedures Test Reports - General Drawings (Undimensional) Procurement Data Packages and Lists Data Accession List/Internal Data As Required Reports Specification Maintenance Document Minutes of Formal Review Inspections and Audits Engineering Change Proposals Procurement Method Coding Document Recoverable Item Breakdown Provisioning Documentation Format Design/Change Notices for Spare/Repair Parts Information Design Change List Production Lists for Spare/Repair Parts Preferred Parts Lists Non-Standard Parts Selected for New Design Request for Nomenclature Engineering Data for Research Technical Order CFAE/CFE Notices Aerospace Ground Equipment Recommendations Calibration Requirements Summary Aerospace Ground Equipment Illustrations	One-Time Requirements Maintenance Manual Operating Manual Overhaul Manual Repair Manual Spare Parts Price List (Overhaul Manual, Repair Manual, Spare Parts Price List: If warranty is not for life of equipment) Spare Parts Procurement Lead-Time Notification Report Initial Provisioning Requirements Report As Required Service Bulletins Manual Changes Warranty Claim-Determination Report Slides, tapes, visual aids, and other training materials as required by buyer Privilege of making video tapes in manufacturer's factory to assist in follow-on training Access to inspection of drawings, stress- and component-analysis results, and consultation with cognizant engineering personnel for discussion of these documents Data necessary for installation, maintenance, and repair of equipment, spare units, and spare parts (if decision is later made to revert to organic maintenance from a warranty program) Engineering drawings and data for installation, service, and repair of test equipment and tooling required for equipment, spare units, and spare parts *United Airlines and Pan American Airways contracts used as reference.

Table 3-5. A COMPARISON OF QUALITY-ASSURANCE PROVISIONS

Military	Provision	Airlines
	R&D Project Test and Evaluation	
Sometimes accomplished in house. If accomplished by manufacturers, documentation must be in accordance with (IAW) MIL Specifications.	Research Test and Evaluation Exploratory Development Test and Evaluation Advanced Development Test and Evaluation	All accomplished by competing manufacturers within AEEC to sufficient detail to achieve FAA TSO certification. Goal is to achieve performance as suggested in ARINC Characteristics published by AEEC with cost compromises sufficient to meet market requirements. Only data requirements are: • Test data to satisfy FAA evaluation (per appropriate RTCA documents) • Engineering data to satisfy interested airlines • Data required for in-house program management
Accomplished by contracted manufacturers to detail prescribed in extensive military specifications, standards, manuals, handbooks, and other publications. Accomplished under contract requiring extensive documentation and reporting of each step. Each major step requires USAF review and approval prior to proceeding to next phase, requiring expensive and time-consuming data management, coordination, and review cycles.	**Development Test and Evaluation** Laboratory Engineering Tests Preliminary Qualification Tests Safety Special Components Preproduction (first article) Evaluation Physical Characteristics Inspection Packaging-Design Inspection Maintenance-Cycle Analysis Reliability Analysis Human-Engineering Demonstration Maintainability Demonstration Safety Demonstration Reliability Tests Functional Parameter Testing Standard Environment Extreme Environment	
	Production Quality Assurance	
In-house USAF testing usually requires extensive duplication of contractors' preproduction evaluation to verify performance.	Initial Production Tests Sufficient testing to verify preproduction evaluation	Accomplished by interested airline to degree necessary to verify that operational requirements are met (with equipment on loan from manufacturer).
Accomplished by contracted manufacturer IAW his own plan, which has been developed IAW extensive USAF MIL Specifications, Standards, Manuals, etc.	Acceptance Testing Individual Tests Sampling Tests Reliability Assurance Tests Special Tests (Design Changes or Failures Evaluation)	No requirement. Manufacturer assumes responsibility through term of life warranty provisions.
When accomplished, testing is usually by manufacturer IAW MIL Specification, Standards, Manuals, and other publications, and requires extensive reporting.	Life Testing	

Warranty coverage has a significant effect on the quality-assurance provisions. Note on Table 3-5 that production acceptance and life testing are major items in the military environment. In the airline situation, however, no requirement is imposed in view of the manufacturer's long-term responsibilities reflected in the warranty.

While some *new* administrative concerns will arise as a result of warranty invocations,[9] there is no reason to believe that the *total* administrative load will significantly increase because of the change from organic to warranty support. This will be especially true after the Air Force has gained some experience with warranty programs now being implemented.

3.4.2.5 Section 5: Preparation for Delivery

In the airline procurement documentation, reference is made to the Air Transport Association's Specification No. 300, Packaging of Airline Supplies, and to the World Airline Supplier's Guide,[4] which identifies the details of packing for shipment and storage to guide the supplier in preventing damage to the product. It also includes marking for identification. The specification is similar in scope to the Military Specifications but is furnished as a recommendation rather than direction. Use of the specification is the manufacturer's responsibility and any damage resulting from improper packing is left to the manufacturer to reconcile.

3.4.2.6 Section 6: Notes

As shown in the description of the *modus operandi* of the AEEC Committee,[37] draft Characteristics are developed in open forum, with technical contributions solicited from all participants. The draft is then reviewed by the full committee. In cases of disagreement or, more frequently, where more than one approach is developed, the ARINC Characteristic contains a "commentary" statement reiterating the pros and cons of the subject, with whatever other guidance may be of value to the users of the document.[25]

There is no evidence of a counterpart for this "commentary" information in any Military Specification; in fact, convention associated with MIL-STD-490 precludes it. The closest approach to such nondirective "guidance" suggested by MIL-STD-490 is found in the Notes section of the specification, where appropriate "technical notes" are authorized but seldom used in the manner that is so effective in the airlines. Convention would suggest that this flexibility has never encouraged the kind of commentary that appears in Characteristic 578. As an example, consider the guidance on interference rejection from Characteristic 578, Item 3.1.9. That guidance is reproduced here as an illustration of the nature of such "commentary" remarks, and suggests that while the wording may not represent a desired DoD style, the guidance can provide motivating influence when used in conjunction with the competitive climate of the commercial market:

> "The probability that this equipment will find itself installed in the same aircraft as a SATCOM communications system capable of putting out 500 watts of power in the 118

to 136 MHz band makes good cross modulation and interference rejection performance of the utmost importance. Modern radios utilizing semiconductor devices for both amplification and tuning have shown themselves to be less capable in this area than their older tubed and mechanically tuned brothers, and manufacturers are strongly encouraged to look for ways and means of improving matters."

3.4.2.7 Comparison Summary

In comparing the specification method utilizing ARINC Characteristics, RTCA documents, and supporting documentation with that utilizing the DoD Engineering Exhibit and the full reference set of Military Specifications, it must be remembered that the two methods reflect basically different approaches. The RTCA documents, as quoted in FAA TSOs, define the equipment Minimum Performance Standards under standard and extreme environments required to provide safe and dependable support of aircraft operations.[19, 20] The ARINC Characteristic defines the performance the production hardware must demonstrate to ensure compliance with the acceptable performance criteria agreed upon by the members of the Airline Electronic Engineering Committee (AEEC) and the manufacturers who supply the equipment. The Characteristic also defines those physical and interface requirements necessary to permit interchangeability, on a form-fit-function level, between different manufacturers' equipment or between generations of equipment from the same manufacturers. Together, these documents provide only "black box" equipment definition. As contrasted with the Military Specification, they do not address the overall system of which the equipments are a part; the processes and services necessary to install, operate, and maintain the equipment; or the manner in which the equipment designer is to provide for the defined performance.

According to the Armed Services Procurement Regulations (ASPR), production procurements generally require a specification; and several alternatives are available (ASPR 1-1202). Most current Military Specifications have been prepared according to the standardizing guidance contained in MIL-STD-490, Military Standard Specification Practices. This document, mandatory for use by all Department of Defense activities, permits a substantial degree of flexibility in specification development, and its current application seems to be influenced more by convention than by direction. It is capable of accommodating development of an equivalent to the ARINC Characteristic, with some limitations, through a change in emphasis on various elements and by use of the form, fit, and function option (MIL-STD-490, C2a).

If the commercial approach is adopted by the Air Force, then, significant changes in the conventions associated with the normal specification will be necessary. Specific comments on content will be made in Chapter Four.

3.5 INFLUENCE OF CHARACTERISTIC APPROACH ON PURCHASING PRACTICES

3.5.1 The Military Process

Contractor selection and negotiation is an area of significant difference between the military and commercial processes. For a military purchase (which uses public funds) vendor selection is a matter of extensive and rigid procedures. The Armed Service Procurement Regulations and DoD, AF, AFSC, AFLC, ESD, and ASD regulations and guidance documents represent a complex of procedures through which each procurement must be carried. The innovative procurement personnel deserve much credit and respect for managing to process the number of procurements they do in the face of such a formidable challenge. Unfortunately, in spite of all the protective measures, satisfactory equipment performance is not assured by this process. A supplier with a performance record that is marginally acceptable can respond to various requirements repeatedly and be afforded an opportunity for selection as the lowest-priced offeror; where such an offeror is successful, the user is denied the benefit of a better-qualified supplier. To establish selection criteria that are restrictive enough to eliminate such offerors is a significant challenge in itself.

In addition, the serious implications of awarding a large single contract has its effects on the procurement process. In recent years, shrinking military buying power had led to consolidation of procurements to enlarge the purchase quantities. The award of "winner take all" contracts can mean bankruptcy or abandonment of the market for some losers -- losers who are not necessarily technically incompetent or economically unacceptable. As a result, the award decisions are frequently protested, and companies apply political pressure for reconsideration through their congressional representatives. Therefore, many pressures are applied to the contracting groups to document and justify the selection process carefully so that the decision is not vulnerable.

3.5.2 The Commercial Process

In contrast to military procedures, the airline process requires each potential supplier to pay the "price of admission" by adapting his product to the market with his own money. He then presents the product (rather than a promise of a product) for consideration by the buyers. By providing a sufficiently attractive product, the new supplier can recover his investment through competition with the established vendors and capture a part of their market.

Considering the large potential military ALS market, it is reasonable to expect that manufacturers will be willing to follow the procedures they employ in commercial procurements. If a market environment equivalent to that which exists in the airline situation is created for the military procurement, we expect that contractors will adapt equipments at their own expense in anticipation of possible sales.

The selection of the contractor is considerably less formal. In some cases, an offeror will be solicited to reconsider his bid in light of a competitor's offer of a better combination of features. However, irresponsible low bidders will be eliminated from the market since their product will either be inferior because of design or manufacturing shortcuts, or their selling price will not support their continuation in business. Revised offers can include price, performance, or other elements; but the award does not shut out the unsuccessful offerors, since other purchases by other airlines can be expected in the immediate future. This latter point is a significant aspect of the commercial process. Anticipation of future purchases provides for continuation of competition throughout the entire production-procurement-operation process. The key is the use of the form-fit-function, industry-developed specifications and segmented procurement, so that if one manufacturer proves to be incapable of providing the desired product, there are alternative sources.

It is also of interest that airline procurements involve small quantities over a longer period and that no single buyer dominates the market.

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CHAPTER FOUR

APPLICABILITY OF COMMERCIAL PRACTICES TO THE MILITARY SITUATION

4.1 INTRODUCTION

In Chapter Three an overall comparison of commercial and military procurement practices was presented. With this background, two major questions can now be addressed. First, what beneficial results might be expected from the use of commercial practices (including specification development by committee) in the military situation? Second, what problems might be anticipated in applying these commercial practices in the military environment?

To provide comment on these questions, ARINC Research investigated the cost, performance, and quality data on military and commercial avionic equipment. The findings are presented in Section 4.2.

In addition, several factors believed to be possible problem areas in the implementation of commercial practices were examined. These factors, broadly characterized as Regulatory/Legal, Technical, and Other, are discussed in Section 4.3. Installation technical factors are discussed in Section 4.4.

4.2 EVALUATION OF COST AND PERFORMANCE PARAMETERS

To evaluate differences to be expected in equipment cost, quality, and performance, available data from some airline and military avionics procurements were assembled and analyzed. The process and results are discussed in the following subsections.

4.2.1 Approach to Comparison

To compare the results of military and airline avionics procurements, particularly in aircraft instrument landing guidance equipment, an extensive data search was conducted. The objective was to identify the cost differences between past conventional military and commercial procurements and use these differences to indicate the results of adapting airline specification and procurement practices for military use. However, differences in individual equipment performance, installation, environment, convenience, technology, quantity purchases, and period of acquisition, coupled with some data

deficiencies, make cost comparisons imprecise. The evaluation, then, considers the most realistic acquisition costs that could be determined, published physical and performance characteristics, and reliability data.

4.2.2 Data Employed

Two lists of ILS equipment types were developed. One represented equipments used by the Air Force; and the other, equipments used by the commercial airlines. For each of the equipments, performance and design data, such as accuracy, selectivity, size, weight, and technology employed, were collected and considered. The basic sources of these data were manufacturers' handbooks, maintenance technical orders, equipment specifications, and in-house reports.[5,6,8] An initial screening on the basis of comparability of Air Force and airline equipments resulted in eliminating several equipments from consideration. Significant data on the remaining equipments are shown in Appendixes D and E.

These data were examined in detail, and a representative cross-section of equipments was selected for further study. For the selected equipments, reliability and cost data were assembled. This information is shown in Tables 4-1 and 4-2, along with summary comments on age, technology employed, and utilization.

4.2.2.1 Reliability

The reliability values shown in Table 4-1 for Air Force equipments were taken from a 1972 ARINC Research report.[6] The figures, expressed as mean times between failures (MTBF), were derived from the Air Force 66-1 maintenance data system. The MTBFs shown are average figures derived predominantly from transport and B-52 aircraft. While there are some considerable MTBF variations among aircraft types, an examination of the complete data set shows no consistent bias that would favor any aircraft type. Therefore, the average figures are considered most appropriate.

The data sources employed permitted eliminating unverified malfunctions from the calculations. Therefore, these figures provide a realistic estimate of mean times between "failures" as opposed to mean times between "removals".

For the airline situation, however, the data sources[8,39] did not provide this distinction. The basic characteristic in this case was mean time between unscheduled removals (MTBUR), and the data could not be modified to eliminate the unverified malfunctions. Therefore, the Air Force and commercial data are not directly comparable. The bias is such that if it had been possible to determine MTBF for the commercial case, the reliability figures shown in Table 4-2 would be higher. In the comparison of Air Force and commercial equipments, it should be remembered that the airline reliability characteristics are conservatively stated.

Table 4-1. REPRESENTATIVE USAF ILS EXPERIENCE

Equipment	Function	MTBF[1] (Hours)	Date Equipment Source Coded	Cost	Remarks
AN/ARN-14	VOR/Localizer	265	1954	4906[1]	Vacuum-tube design, with nearly 20 years of reliable service. Installed in all classes of aircraft, including many fighters, most transports, and entire B-52 Fleet.
AN/ARN-31	Localizer/ Glide Slope	300	1959	852[2]	Vacuum-tube design, with more than 15 years of reliable service. Designed for fighter or other space-limited aircraft; also used in B-52G.
AN/ARN-58	Localizer/ Glide Slope/ Marker Beacon	443	1961	1896[3]	Transistorized equipment; consists of three separate receivers; designed for space-premium aircraft. Installed primarily in A-7, F-111, T-38.
AN/ARN-18	Glide Slope	772	1955	450[3]	Vacuum-tube design -- the usual companion of ARN-14 in all classes of aircraft. Has provided nearly 20 years of reliable service.
AN/ARN-67	Glide Slope	1,623	1962	2381[4]	Transistor design, used as replacement for ARN-18 primarily in late model B-52 aircraft.
AN/ARN-12	Marker Beacon	941	1954	1757[3]	Vacuum-tube receiver of simple design. Used in all classes of aircraft for 20 years, with good performance and reliability.
AN/ARN-32	Marker Beacon	857	1959	1038[3]	Same quality as ARN-12, with about 15 years of reliable service.
Wilcox 806A	VOR/Localizer	275	1965	3069[2]	Transistor design; installed primarily in WC-135B, EC-135, RC-135, and C-141A.
Collins 51V4	Glide Slope	918	1963	2550[4]	Transistor design, installed only in the C-141A.
Collins 51Z3/51Z4	Marker Beacon	2,045	-	372[3]	Transistor design, excellent performance and reliability, is used by commercial airlines as well.
Wilcox 800B	Glide Slope	918	1965	1490[3]	Transistor design, installed as the companion to the Wilcox 806A in the C-141A and with the AN/ARN-67 in several other USAF aircraft.
VOR-101	VOR/Localizer	300	-	6365[5]	ILS equipment incorporating other basic localizer receivers as they have become available. Installed primarily in the HC-130H/P/N, WC-135B, and C-141A.

1 *Cost Study of Selected Communications, Navigation, and Identification Equipments*, ARINC Research Corporation, prepared for Electronics System Division, F19628-72-C-0071, June 1972.

2 WRAMA D041.F91A, "Cost Analysis Factors" printout.

3 RAD-043, *Communications/Navigation/Identification/Cost Development Study*, June 1970.

4 ASD/SMC-1, *GFAE Impact Listing*.

5 ASD, *Consolidated Aerospace Equipment List (CAEL)*, printout, November 1971.

Table 4-2. REPRESENTATIVE AIRLINE ILS EXPERIENCE

Equipment	Function	MTBUR* (Average for Two Years) (Hours)	Remarks on MTBF	Representative Catalog Price 1968-1972**	Assessment of Quality and Performance
Collins 5IRV-1 5IRV-2B	VOR/ Localizer/ Glide Slope	1,515	~1,000 hours in L-1011, which has installation problem; up to 5,000 hours elsewhere.	$5,312[1] $8,788[2]	The extensive screening of high-quality commercial components has produced the commercial equivalent of high-reliability military components. Performance has been satisfactory for most airline applications. Category C (DO-138) temperature-altitude qualification (-40° C to +55° C) may not be adequate for the L-1011 environment.
Collins 5IR1 & 5IR3	VOR/ Localizer	1,250		$3,000	Commercial-quality equipment, but designed more than 20 years ago, with vacuum-tube technology. Equals ARN-14; uses many of the same components. Reliability attributable to good design, good manufacturing techniques, and full maturity.
Bendix RNA-26C	VOR/ Localizer/ Glide Slope	660	530 to 830 hours reported during the 2-year period studied; current MTBF about 2,000 hours.	$5,644[1]	Commercial-quality equipment designed 10 years ago. Because of good performance and high cost of replacement, many airlines transferred this equipment from their propeller fleet to the new jet fleet and bought additional sets of the same model.
Wilcox 706A	VOR/ Localizer	660	Reported limits: 500 to 850 hours.	$2,500	The last tube-type VOR designed by Wilcox. Many of these equipments have delivered up to 1,000 hours MTBF and were retained during conversion to jet aircraft.
Wilcox 806A	VOR/ Localizer	1,750	Reported limits: 700 to 2,000 hours.	$3,480[1]	Commercial-quality equipment using transistor technology and new packaging for easy maintenance. Good performance and high reliability contributed to popularity, repeat sales, and retention in service.
Collins 51V4	Glide Slope	3,570	Reported limits: 1,600 to 10,000 hours.	$1,335[1]	Commercial-quality equipment. 51V4 is the first transistor type (designed in early 60s).
Wilcox 800B	Glide Slope	2,780	Reported limits: 1,600 to 5,000 hours.	$ 968[1]	Commercial-quality equipment. 800B is the first transistor type (designed in early 60s).
Bendix MKA-28D Collins 51Z4 Wilcox 702A	Marker Beacon	2,800 2,080 2,850	Recent experience indicates that marker beacons in use are achieving MTBF figures well in excess of 5,000 hours.	$ 400 $ 610[1] $ 400	Marker beacon receivers, because of their simplicity, are inexpensive and highly reliable. Failure under 5,000 hours has been rare. Typical MTBF has remained in the 10,000-hour category for at least 5 years.

*Most airlines do not use MTBF computations to monitor reliability. Hence, the figures above represent mean times between unscheduled removals extracted from statistical monitoring reports published by various airlines of the Avionics Maintenance Conference. These MTBUR figures, then, represent a pessimistic estimate of airline equipment reliability.

**The procurement information available is the catalog price per unit of equipment. Discussion with airline procurement personnel and avionics equipment manufacturers indicates that competitive discounts are accorded commercial carriers. Specific discount figures are considered proprietary; however, some sources indicate that they range up to as much as 50 percent in outright cost adjustment or other pruchase/service arrangements. Data on quantities purchased and dates of purchase were not available.

1 Advertised prices, April 1968.

2 *Survey of Commercial Airline and General Aviation Navigation Avionics Equipment*, prepared for SAMSO/AFSC by ARINC Research Corporation, July 1973.

4.2.2.2 Cost

The cost information shown in Tables 4-1 and 4-2 was derived from the sources indicated. Commercial prices represent advertised "list prices" taken from manufacturers' published information. These prices are essentially those offered in the 1968-1970 period. It is important to note, however, that discounts and other considerations offered by manufacturers may reduce the "list prices" by as much as 50 percent.

Determination of Air Force equipment costs involved a major problem, one which could not be satisfactorily resolved. Cost data were derived from the sources indicated in Table 4-1. No single source provided information on all equipments. When data were available for the same equipment in more than one source, there were often variations. In some cases the unit prices in one source were twice as high as those cited in another. Further, some sources showed a total equipment price equivalent to the price shown for a major component in another source.

This lack of consistency militates against the presentation of definitive cost data. The cost information in Table 4-1 is presented so that gross cost comparisons may be made. The cost sources selected were chosen on the basis of judgment concerning which were most reasonable. To assure as much objectivity as possible, the judgments used were those made in a 1972 ARINC Research study. That study was concerned only with military equipment costs, so that the source selections were in no way influenced by a knowledge of airline prices.

4.2.3 Comparisons

Examination of Tables 4-1 and 4-2 and Appendixes D and E permits some general observations to be made concerning relative cost and quality of Air Force and commercial equipments. Table 4-3, developed to facilitate the comparison, is organized so that Air Force and commercial system configurations believed to be approximately comparable in terms of performance characteristics and age are shown in three groupings. In general, all Air Force and commercial equipments that perform the same function exhibit comparable accuracy and sensitivity and similar basic operational characteristics.

Because of the difficulties encountered in establishing accurate Air Force procurement costs, it is not appropriate to make conclusive statements about cost differences between military and commercial procurements. While it is difficult to estimate the accuracy of the military costs, the variations observed in the sources suggests that the total costs cited for the first four configurations could be about 20 percent high. (There might also be an error in the other direction. However, in order to be as conservative as possible in the comparison, we shall comment only on the possible overstatement of cost.) It is of interest to note that if the costs were reduced 20 percent, they would still exceed the comparable airlines costs.

In the fifth military configuration, it is possible that a larger overstatement of costs is involved. If this is the case, the military

Table 4-3. A COMPARISON OF USAF AND AIRLINE ILS EQUIPMENT CONFIGURATIONS, 1968 - 1970

USAF					Airline				
Typical System Configurations	Function	MTBF (Hours)	Initial Cost (Dollars)		Manufacturer	Typical System Configurations	Function	MTBUR	List Price (Dollars)*
ARN-14	VOR/Localizer	265	4,906	Approximate Equivalents	Collins	51R3	VOR/Localizer	1,250	3,000
ARN-18	Glide Slope	772	450		Collins	51V4	Glide Slope	3,570	1,335
ARN-12	Marker Beacon	941	1,757		Collins	51Z4	Marker Beacon	2,080	610
		Total	7,113					Total	4,945
ARN-14	VOR/Localizer	265	4,906		Wilcox	706A	VOR/Localizer	660	2,500
ARN-67	Glide Slope	1,623	2,381		Wilcox	800B	Glide Slope	2,780	968
ARN-32	Marker Beacon	857	1,038		Collins	51Z4	Marker Beacon	2,080	610
		Total	8,325					Total	4,078
ARN-14	VOR/Localizer	265	4,906						
ARN-18	Glide Slope	772	450						
ARN-32	Marker Beacon	857	1,038						
		Total	6,384						
VOR-101	VOR/Localizer	300	6,365	Approximate Equivalents	Wilcox	806A	VOR/Localizer	1,750	3,480
ARN-67	Glide Slope	1,623	2,381		Collins	51V4	Glide Slope	3,570	1,335
51Z-4	Marker Beacon	2,045	372		Collins	51Z4	Marker Beacon	2,850	610
		Total	9,118					Total	5,425
806A	VOR/Localizer	275	3,069	Approximate Equivalents	Wilcox	806A	VOR/Localizer	1,750	3,480
51V4	Glide Slope	918	2,550		Wilcox	800B	Glide Slope	2,780	968
51Z-4	Marker Beacon	2,045	372		Wilcox	702A	Marker Beacon	2,850	400
		Total	6,991					Total	4,848

*Discussion with airline procurement and avionics equipment manufacturers indicates that substantial competitive discounts are accorded commercial carriers in the market place. Specific discount figures are considered proprietary; however, some sources indicate that they vary as much as 10 percent - 50 percent in outright cost adjustment or other purchase/service arrangements.

costs could be lower than the commercial list prices. The reader is reminded, however, that the commercial figures are "list prices" and that substantial discounts may be applied.

In relation to reliability, the commercial equipment is consistently superior to equivalent military equipments. In comparable installation configurations, each airline equipment exhibits a higher reliability than any Air Force equipment performing the same function. In most cases, the difference is appreciable. The reader is also reminded that, as discussed in Section 4.2.2, the reliability measure selected for airline equipment is conservative in comparison with the military figure. An increase of 30 percent over the MTBUR figures shown would not be an unreasonable correction factor to employ to make the two mean times comparable.

The total difference, however, cannot be attributed to the hardware. Variations in maintenance policies and procedures can influence reliability, as can aircraft environmental factors. Nevertheless, it appears that a significant reliability advantage accrues to the airlines. Analysis of the comparative data for installations of systems with equivalent performance capability shows that the military equipment usually exhibits lower reliability, as reflected by a higher rate of unscheduled removals.

In the area of cost, a lack of conclusive data militates against a definitive statement on cost differences. It should be noted, however, that the cost comparison presented above deals only with acquisition costs. Support costs, which were not evaluated, are heavily influenced by equipment reliability.[24] Figure 4-1, taken from a recent ARINC Research report,[5] shows the effect of MTBF variation on logistics support cost. This curve was generated for the Defense Navigation Satellite System receivers by using an adaptation of the AFLC Life Cycle Logistic Support Model. The figure is shown only to demonstrate the *shape* of a typical support-cost curve, since the abscissa values are dependent upon quantity and life-cycle period. It does illustrate, however, the proportionate savings attributable to higher MTBFs.

Joint consideration of the acquisition-cost data and the influence of higher reliability on support costs strongly suggests that the airlines enjoy an overall cost benefit.

4.3 POSSIBLE BARRIERS TO MILITARY USE OF COMMERCIAL PROCESS

In recognition of the significant differences between the military and commercial situations, factors that might represent barriers to the use of commercial practices in the military environment were analyzed. The conditions that create concern over these factors can be generally categorized as regulatory/legal, technical, and "other". (The specific technical factors concerning equipment installation are treated in Section 4.4.)

4.3.1 Regulatory/Legal Factors

The Armed Services Procurement Regulations (ASPR) and supplementary DoD directives establish a complex array of policies and procedures govern-

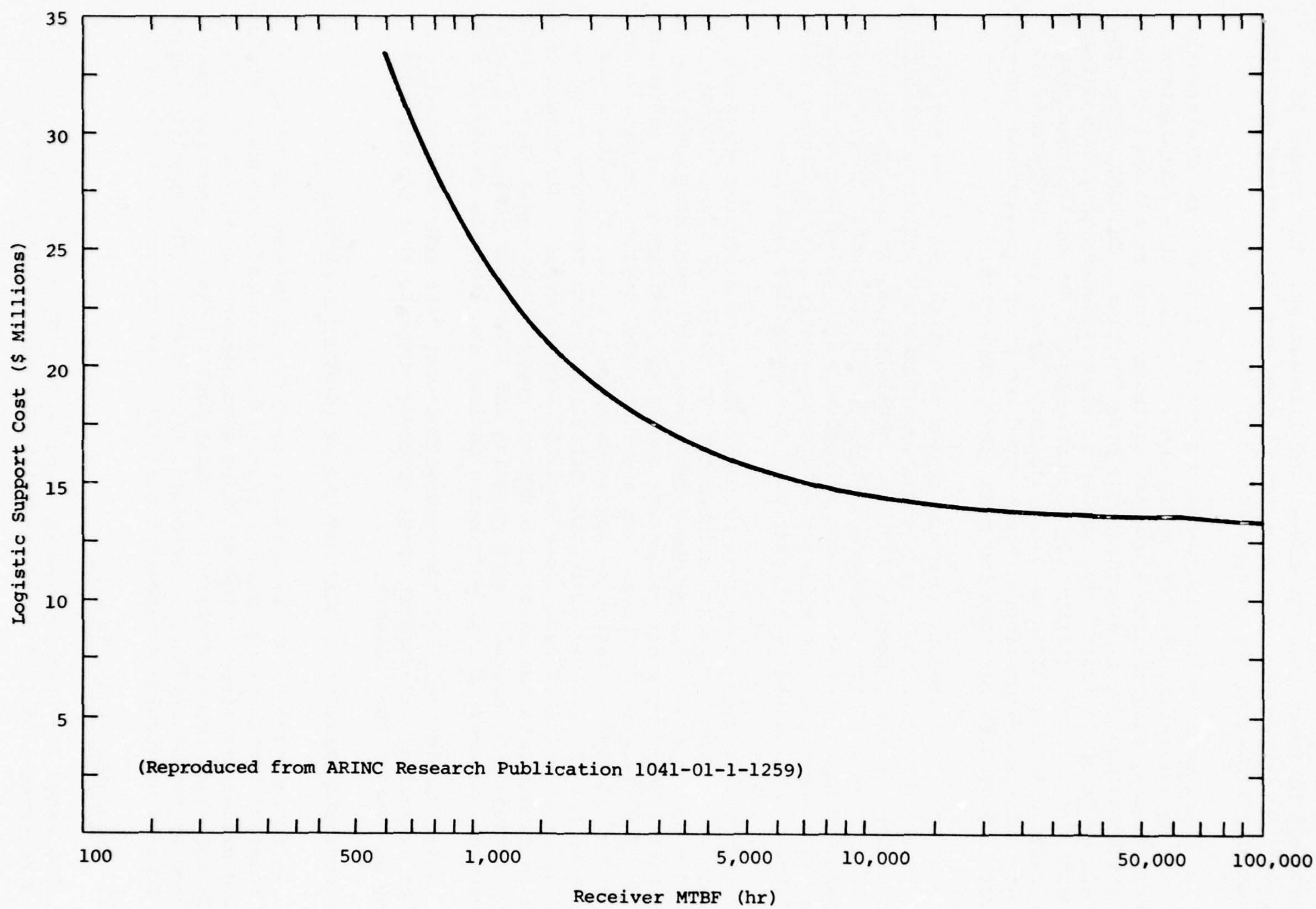

Figure 4-1. LOGISTIC SUPPORT COST VS. MTBF FOR DNSS RECEIVER

ing procurement by the various Department of Defense agencies. These are further augmented by Air Force, AFSC, AFLC, and ESD guidance documents. In spite of the formidable appearance of these documents, a degree of flexibility is permitted. Operation within the bounds of these directives appears to be dominated more by convention than by specific policies and procedures.

To assist in evaluating the possible effects of the existing regulations, the principal influencing directives were reviewed; then a possible method for Air Force use of commercial practices in the ALS procurement was hypothesized. Comments on the viability of the approach were then solicited from Air Force procurement professionals and management personnel, who suggested changes to facilitate implementation within an evolving directive structure. The comments provided by the Air Force procurement community were extremely helpful in setting the possible course of action in the proper perspective.

In the following subsections, comments are presented on four basic regulatory/legal factors: Committee Operations, Anti-Trust, Conflict of Interest -- Allegation of Conflict, and Procurement Procedures.

4.3.1.1 Committee Operations

One of the legal problems is related to the development of the specifications. To permit the development of Military Specifications for the ALS in a climate similar to that used for the development of airline Characteristics, an open forum should be established. In utilizing such a forum, care must be taken to insure compliance with PL 92-463, "The Federal Advisory Committee Act", and OMB Circular A-63. One of the principal purposes of the Act is to prevent collusion, price fixing, or restraint of trade, which could result from restricted public access to full particulars related to information influencing a potential future procurement. The Act requires a "fishbowl" process.

4.3.1.2 Anti-Trust

Airline personnel and others responsible for arranging AEEC committee deliberations have been acutely conscious of the importance of avoiding any possibility of anti-trust violations in conducting industry meetings. To avoid anti-trust problems and to comply completely with the Federal Advisory Committee Act, all personnel involved in any TRACALS/ALS Advisory Committee will have to exercise care to assure the following:

- That all meetings are conducted openly and with government representation
- That there is no discussion of prices
- That any cost discussions are limited to the general cost implications of different technical approaches
- That there is no possibility of group action that could penalize nonparticipating manufacturers, favor any manufacturer or group over another, or in any way limit effective competition for the government's business

4.3.1.3 Conflict of Interest -- Allegation of Conflict

Some may allege that the airline open-forum committee meetings may place participating vendors in a conflict-of-interest position. However, since these meetings would be open to the public, anyone could attend and thereby become familiar with the evolution of the ALS specification.

Appendix G of ASPR sets forth certain rules for the "Avoidance of Organizational Conflicts of Interest". Rule 2.b. is set forth below:

> "2. If a contractor agrees to prepare and furnish complete specifications covering nondevelopmental items to be used in competitive procurement, that contractor shall not be allowed to furnish such items, either as a prime or subcontractor, for a reasonable period of time including, at least, the initial procurement. This rule shall not apply to:
>
> a. Not applicable.
>
> b. Situations where one or more contractors acting as industry representatives assist Department of Defense agencies in preparing, refining or coordinating specifications, regardless of source, which assistance is supervised and controlled by Government representatives."

It is believed that the open-forum type committee, meeting with full industry participation, is within the exception of Rule 2.b. of Appendix G of ASPR cited above.

4.3.1.4 Procurement Procedures

The procurement process can be modified if necessary, or deviations granted; but it is flexible enough so that experienced and imaginative Air Force procurement personnel can achieve the desired objectives through alternative procedures and reinterpretation of the regulations. One point commented on by many of those interviewed was the basic factor in ASPR 1-100, which states that the ". . . ASPR is not intended to stifle the development of new techniques or methods of procurement. Innovations to obtain desirable objectives will occasionally necessitate deviations from ASPR . . ." Most interviewees felt confident that the basic process could be followed within present regulations but that if a situation arose in which a conflict could not be reconciled, a deviation might be granted by the ASPR Committee or a change in regulations could be pursued. Basically, however, the use of techniques that promote free and open competition would not conflict with the intent of the regulations.

Procurement specifications are generally required by ASPR for any production purchase. Specifications developed by the ALS Committee must be

supplemented by additional documents, identifying all contractual items, to permit selection of the lowest qualified bid or the purchase of several alternate but interchangeable equipments from several suppliers on the basis of a cost/capability assessment. Without compromising current directives, the necessary specifications can be assembled and applied without extensive manufacturer reporting requirements or monitoring.[38]

4.3.2 Technical Factors

4.3.2.1 Specification Content

Because of the basic difference in philosophies in the current military and commercial procurement approaches, there are significant differences between the Specification and the Characteristic. If the military chooses to adopt the airlines approach, the resultant specification would not include all of the items currently employed in Military Specifications. Implicit in the form-fit-function specification, for example, is a departure from the piece-part-configuration-control detail currently encouraged by MIL-STD-490, MIL-E-5400, MIL-STD-454, and ANA-400. Relinquishing such control will not necessarily cause as serious a support problem as is frequently suggested. Under the present procurement philosophy, there has been extensive proliferation of different systems to meet relatively minor variations in application. Furthermore, within a particular design, modifications and ECPs have produced a multiplicity of configurations that compromise the degree of control achievable. As a result, the advantages of broad standardization are lost and the user is still denied the advantage of interchangeability between system components.

In general, if the commercial procurement approach is used, some specification provisions may no longer be necessary. On the other hand, some may still be desirable. The military Program Manager must ultimately decide which requirements are to be retained and provide for them in much the same way as the airlines. Generally, warranty coverage over the life of the equipment should permit elimination of many specification provisions and DD 1423 reports. In addition, references that control the manufacturer's activity rather than product performance may be easily deleted.[14]

Retention of Specification Provisions

In this effort, no attempt was made to perform an exhaustive review of all possible specifications that could be invoked in the ALS production procurement. Rather, more general guidelines to assist in the selection of supporting specifications are offered on the basis of a review of the ARN-XXX supporting references.

If the ALS equipment is to be manufactured in a highly competitive environment, according to form-fit-function requirements, the ALS specifications should be quite similar to ARINC Characteristics. Performance requirements must be identified, but the usual "how to do it" specifications should be eliminated. In a few cases, such as those defining the methods for measuring performance, it is most appropriate that the method of

measurement be contained in the contractual Work Statement rather than in the equipment specification. Table 4-4 lists two sets of reference documents. The first set cites those documents considered appropriate within the specification. The second list contains those publications that may be incorporated in the Work Statement. Other publications are not considered essential to this procurement and should be included only in those cases where adequate justification can be developed.

Table 4-4. PUBLICATION REFERENCES

Document Category and Number	Title	Date
Publications to be Cited in Equipment Specification		
ARINC 404A	Air Transport Equipment Cases and Racking	15 March 1974
MIL-STD-704A	Electric Power, Aircraft, Characteristics and Utilization of	9 August 1966
ICAO Standard	Annex 10 to Convention of International Civil Aviation Organization (amended March 1972)	
Publications to be Cited in Appropriate Tasks Included in the Contractual Statement of Work		
MIL-N-18307	Nomenclature and Identification for Electronic, Aeronautical, and Aeronautical Support Equipment	29 February 1972
MIL-STD-130	Identification Marking of U.S. Military Property	5 March 1971
ARINC 568	Mark 3 Airborne Distance Measuring Equipment	1 June 1971
RTCA Document	Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments	

DD Form 1423 Items

Of particular interest are the data requirements normally called for on the DD Form 1423. Purchase of ALS equipment through an Air Force adaptation of the ARINC Characteristics/AEEC equipment development and procurement process would eliminate the requirement for most of the 1423 development data now contracted for. To help establish the items to be retained, the AN/ARN-XXX Contract Data Requirements List, DD Form 1423, as revised 25

October 1972, containing development and production data requirements, was examined. Later revisions of this list accommodated three different maintenance concepts: (1) no organic maintenance under a warranty program, (2) initial warranty followed by organic maintenance, and (3) total organic maintenance. The latest revision was not available for use in preparing this report and, in any event, reflects a conservative approach that retains many data requirements simply as a "backup".

Most of the Form 1423 data requirements found in contracts such as the AN/ARN-XXX contract are not applicable because of the very nature of the proposed procurement process, i.e., no Air Force contract for development; total manufacturer responsibility, at least initially, for product performance; and the competitive market environment. Further, assuming full life-cycle warranty provisions, many other data requirements may be eliminated; others may be combined. By the time ALS equipment is purchased by the Air Force, warranty administration data requirements should be well documented and the requirements list presented here may be modified.

By using the AN/ARN-XXX Form 1423 data requirements list as a reference, a suggested list of data requirements to be retained for an ALS equipment purchase was developed. This list, presented in Table 4-5, was developed primarily to assist in reducing the number of general areas to be covered so that significant savings could be realized in initial data preparation, data management, and review.

Several data items not included in the recommendations of Table 4-5 merit mention:

- The information contained in the traditional Progress Curve Report, DI-F-3207, should be developed in negotiations. The Procurement Method Coding Document, DI-P-3461, identifying proprietary rights, loses significance when only form, fit, and function are purchased.
- Within the assumptions of this study, engineering, configuration control, reliability and maintainability control, parts control, production monitoring, provisioning, and maintenance-data requirements are not required so long as the manufacturer is responsible for all maintenance, other than LRU removal/replacement and checkout, and for the product's performance via warranty provisions.
- Most Air Force personnel contacted suggested that the existing, rather detailed T.O. format is required to meet Air Force maintenance-personnel skill levels. However, assuming that warranty provisions are included, the technical requirements in removing/replacing and testing LRUs are more than met in typical manufacturers' maintenance and operating manuals. The cost savings in substituting these manuals for the T.O. development and management system are substantial.
- Manufacturers' plans for specific programs such as electromagnetic compatibility, reliability, maintainability, and testing -- ostensibly required to assure satisfactory performance -- are applicable only to the extent that initial equipment-performance demonstration is

Table 4-5. RECOMMENDED CONTRACT DATA REQUIREMENTS

Procurement Method Information, DI-P-3473

Identifies source of parts used in production.

Decalcomanias and Other Markings, DI-L-333A

Identifies manufacturer's product markings for USAF review.

Numerical Parts List, DI-V-3811

Provides description of manufacturer's component identification system (should incorporate all parts and subassemblies, may be incorporated in a report and also identifies parts cost).

Training Support Data, DI-H-3258A

Provides information essential to personnel training.

Identification List of Standard/Modified Hand Tools, DI-V-3284

Preservation and Packaging Report, DI-L-3305

Identifies manufacturer's preservation and packaging experience for future reprocurement use, also identifies methods of preservation and packaging of product by USAF during shipment/storage or upon return to manufacturer.

AGE Recommendations, DI-5-3596

Calibration Requirements Summary, DI-5-3615

Data Accession List/Internal Data Report, DI-A-3077

Principally used to determine manufacturer's compliance with requirements. Use could be changed to provide a source of non-contract data information when/if required at a later date.

Manufacturer's Maintenance Manual

Manufacturer's Operating Manual

Bulletins and Manual Updates

Engineering drawings and data for installation, service, and repair of test equipment.

Warranty Administration Data

necessary. This demonstration could be performed by one of the appropriate Air Force laboratories. However, product performance must be proven in service to demonstrate acceptability.

- The formal review, inspection, and audit procedures, and the related reports are not applicable to the proposed acquisition process. Where the Air Force program manager does review a manufacturer's progress, the exchange should be one of suggested changes to make the product more likely to meet the Air Force requirements. Consideration must be given to the cost such changes may involve or to assuring that they can be incorporated without added cost to the Air Force. The manufacturer bears the responsibility for the marketability of his product in the competitive arena and should consider any recommendation in the light of the competitive situation. Reports documenting such changes should be prepared by the Air Force personnel responsible for recommendations.

The principal differences between the two procedures are the military dictation of design detail, with extensive and detailed reporting for ancillary elements, and the form-fit-function parameters identified in the commercial purchase. The airline procurement merely identifies the elements the manufacturer must consider if he intends to compete against the others. Except for TSO tests and any qualification tests that the airline or the manufacturer may perform to identify salient characteristics, it allows the proof of performance to be determined in actual operation. The artificial aspect of control documentation is then removed, eliminating a costly manufacturer requirement as well as a requirement for a large staff of airline personnel to receive, analyze, and utilize the data that would have been generated.

4.3.2.2 Costing Requirements

During the course of the committee specification development, it will be necessary to assess the cost implication of the design alternatives considered. Because of anti-trust considerations, cost discussions cannot take place with potential hardware vendors in attendance. This should pose no serious obstacle to the development of an acquisition-cost goal for the ALS by Air Force personnel.

Cost estimates can be made from two basic approaches. First, cost-estimating relationships may exist or may be developed for similar avionics systems to express acquisition cost as a function of one or more technical parameters. The second method requires making detailed estimates of materials and manpower required to produce the system. Each approach would be utilized to provide a means of cross-checking the validity of the other.

The initial cost estimates should be made as soon as the committee has identified the basic functional design concept. The estimated unit acquisition cost may be compared with program criteria for the amounts affordable in the context of the total installation required and the funds available. Design trade-offs may be required if estimated costs exceed program limits.

The final selected functional design should have associated with it an acquisition (flyaway) cost. This cost should be used in future ALS procurements by the Air Force to evaluate potential vendors' prices relative to the program objectives.[13,23,35]

Complementary to the design-to-cost activity, an assessment of the life-cycle-cost implication of the system should be conducted. Steps associated with life-cycle-cost analysis include the following:

1. Select and adopt an appropriate LCC model
2. Acquire requisite data to exercise model
3. Compute life-cycle cost
4. Perform sensitivity analysis to determine major factors that influence LCC

The AFLC LCC model can provide the basic model for consideration. Its cost elements would have to be reviewed systematically to determine their relevancy to the ALS.[24]

Sensitivity analyses can be performed after the basic model has been structured and the data base assembled. The sensitivity of reliability, maintainability, spares quantities, and pipeline parameters to life-cycle cost are key areas of analysis. The impact of warranty or contractor maintenance is another key area that the LCC analysis should address.[9]

As with design-to-cost, the life-cycle-cost analysis should be performed in parallel with the committee specification development. Results of the life-cycle-cost analysis should be fed back to the committee to be used as guidance for selecting the concepts that not only meet technical performance requirements but also are affordable.

Use of both design-to-cost (DTC) and life-cycle cost during the procurement process should serve as advisory activities rather than as specific contract requirements. While it is recognized that DTC and LCC have been used as incentive parameters in contracts to some extent, the administrative complexity of such programs is considered too difficult. It is suggested that, instead, a reliability-improvement warranty be used in association with an MTBF guarantee since these provide some measure of cost control and provide assurance of product quality in the field environment. Warranties are discussed in the next section.

4.3.2.3 Warranty Considerations

The reliability-improvement warranty (RIW)[16] provides that the equipment contractor repair or replace, on a fixed-price basis, all items that fail during the period of coverage. Recent RIW programs have been for periods of three to five years. The long-term arrangement makes the manufacturer responsible for field performance over an appreciable period of the equipment's life. The manufacturer is reimbursed for the maintenance service on the basis of a fixed price computed prior to the unit's introduction to

the field; the price is predicated upon the expected reliability levels. Should the equipment perform poorly, the manufacturer can lose money unless he takes appropriate action to remedy the situation. Conversely, if the equipment exceeds expectations, he will receive added profits because of reduced maintenance expense. Subject to Air Force approval, the contractor is permitted to install no-cost ECPs that he believes will improve system reliability or maintainability.

The MTBF guarantee is another form of warranty recommended for consideration for the ALS. Under this guarantee, the manufacturer must meet a prescribed field MTBF within a stated period. Failure to meet the MTBF value requires the manufacturer to loan to the user a stated number of additional spare units computed on the basis of a formula contained in the contract. Additionally, the manufacturer is required to take steps to improve the system design. If the equipment is not improved within the agreement period, the loaned spares become the property of the user. Of course, if the equipment achieves the required reliability, the loaned spares are returned. The purpose of the loan of spare units is to provide additional assets to maintain the logistic pipeline while the manufacturer attempts to improve the product's reliability.

The two warranty plans are considered to form a major mechanism for achieving the required system reliability and maintainability performance. The use of RIW also provides field and depot maintenance during the period of coverage. Most RIW programs contain an option for renewal in the event it is decided to extend the coverage.

Steps for application of warranty include the following:

1. Develop basic provisions to be included in warranty
2. Perform economic analysis of warranty versus organic maintenance
3. Assuming warranty shows an economic advantage, develop final provisions for inclusion in production RFP
4. Evaluate warranty proposals to determine their cost benefits
5. Administer warranty program

Selection of warranty and the proper term of the coverage are largely predicated on an economic analysis. A warranty cost model[9] developed by ARINC Research provides an analysis framework for considering the cost differences between warranty (for various terms) and organic maintenance. The model output also provides an estimate of a reasonable price for a warranty, since the final decision on warranty must be made after the manufacturer's bid is received.

Administration of the warranty is aided by establishing a requirement for the contractor to acquire and report selected data regarding the warranty repair activity. From these data, not only can some insight regarding the product performance be gained, but valuable information applicable to warranty-extension negotiations may be obtained.

4.3.3 Other Factors

In addition to the legal, regulatory, and technical factors enumerated in the preceding sections, other factors were considered, as described in the following paragraphs.

4.3.3.1 Resistance to Change

To proceed with the recommended specification development process set forth in Chapter Five, advance planning and coordination will be essential[14] to overcome the human resistance to change from the status quo to an innovative and possibly challenging approach. This resistance can be expected at all levels within the Air Force, DoD, OMB, and even Congress. Air Force and DoD approval will be required to use an adaptation of the airlines procurement method rather than the more traditional DoD procurement process, including the specification development. The Federal Advisory Committee Act (PL 92-463) also requires the Office of Management and Budget to approve the establishment of any new "Advisory Committee". It can be expected that this approach will be challenged at various levels, and the project personnel in the TRACALS/ALS SPO should be prepared to defend the approach at many levels. Personnel with personal interests in existing organizations and facilities can also be expected to resist testing this approach.

It is also possible that some operational commanders will resist the concept of contractor support that warranty coverage involves. Such concern with the possible reduction of operational capability as a result of dependence on contractors for maintenance is certainly understandable. However, a general trend to rear-echelon maintenance may be necessary for more basic reasons than those involved with warranties. Increasingly complex equipment and the lower educational level of military technicians have already strengthened the case for "black box" or module replacement. This approach requires sparing at higher levels of complexity and greater dependence on rear-echelon maintenance. Transition to this concept will entail difficulties, of course; but as these are resolved, the use of warranties will become of less concern to the operational units.

4.3.3.2 Competition

A basic policy of federal procurement is to promote free and full competition, and DoD has established very detailed and elaborate procedures to ensure that this policy is carried out. To the novice who is not familiar with the extensive competition that surrounds airline procurement, it may appear that using the airline procurement method will inhibit competition. In reality, however, it encourages all facets of competition, including price, performance, and delivery, as long as the equipment continues to be utilized.

For ALS avionics, which will have its equivalent in the commercial market, the approach offers considerable promise since the research and development for the system elements will be basically complete and the technological base for production equipment will have been established. (Actually, the base is currently being developed under government funding

for MLS and ALS, and it is assumed that it will be completed by the time the production procurements are initiated.)

The "winner take all" situation in the military, in which competition is effectively removed following contract award, must be modified if the airline approach is to be viable. It is essential that a continuing market be maintained if the suppliers are to continue to provide a competitive influence.[10]

Competition following award of the initial production contract is retained in the airline community by each user's making a series of small unit purchases rather than a single large purchase. Because of the form-fit-function specifications, various vendors' products are interchangeable. Users do not encounter higher unit prices because of small purchase quantities since, in establishing their prices, vendors consider their total production run based on an assessment of the total market and their share.

Maintenance of competition requires that multiple production awards be made and that subsequent lots be contracted for on the basis of achieved price-performance. If the manufacturer knows that there is a potential for future sales, he is motivated to improve his product and price.

A comparable approach that we recommend the Air Force consider is to segment the purchase of a quantity of items into smaller increments over a defined period, each purchase independent and competitive, so that all potential suppliers are continually motivated to upgrade their offering and bid on the next purchase. While this seems to conflict with the benefits suggested in larger-quantity procurement, recent analyses have shown that in avionics-type equipments, the cost savings realized through a competitive, segmented acquisition program can exceed "learning curve" cost benefits of quantity purchases by approximately 20 percent.[14]

4.3.3.3 Delays in Procurement Cycle

Since the open-forum process for specification development is time-consuming (as opposed to the usually more expeditious Military Specification-development process), it might be argued that the open-forum approach will unnecessarily lengthen the procurement process. Although this is theoretically possible, the use of long-term warranties in association with the procurement eliminates the requirement for a number of procedures. Coordination with the offices responsible for those procedures can also be eliminated. The overall development and coordination may thus be no longer, and perhaps may be shorter, than the current military process.

4.3.3.4 Personnel Relationships

Development of the TRACALS Specification in an open forum requires an open and free exchange between participants. The trust and understanding developed in the AEEC Committee that produces the desired results is a product of a stable membership. TRACALS Committee members must be long-term participants to promote this respect and maximize the opportunity for candid dialogue.

When changes to procedures of long standing are proposed, particularly those which imply reductions in effort or in personnel requirements, strong personal threats are felt by those in the critical areas. These individuals may exert inhibiting pressures on the implementing groups through the threatened members' management or through Congressional representatives.

4.4 INSTALLATION IMPACT ON AN ALS "CHARACTERISTIC"

4.4.1 Introduction

An important element in the evaluation of the feasibility of developing an ARINC Characteristic type specification for use in the ALS Program is the impact of the physical and environmental differences in the aircraft types in the Air Force inventory.

For the ALS, the practical application of ARINC-type Characteristics will depend on the amount of standardization that can be obtained between systems installed on the various Air Force aircraft types, as well as between the Air Force equipments and their civilian counterparts intended for airline and general-aviation use. A recent study by several graduate students at USAFIT concluded that large Air Force transport aircraft could use commercial (ARINC Characteristic) systems with no foreseeable installation problems, but that installation space and environments found in operational fighter aircraft were not compatible with the commercial systems. The study considered installation in the C-5A, C-130E, FB-111A, and F-15. An underlying assumption was that the ALS avionics would be built to standard ATR dimensions per ARINC Specification 404 and tested to the environmental levels described by RTCA DO-138. During the investigation of installation problems conducted by ARINC Research, the findings of the USAFIT study were carefully considered.

Three versions of the ALS are contemplated. They are described as follows:

- The *Austere* ALS is intended to provide ICAO Category I service. The aircraft requiring this level of equipment will have course-deviation indicators or flight directors but will not have automatic approach systems. This avionics configuration will include an angle receiver/processor, an antenna, and a control panel. The receiver will have a pilot-selectable, constant-angle glide slope and selectable straight-approach paths enabling the pilot to choose the optimum approach course. In an effort to minimize the costs of these airborne units, range information may have to be provided by the TACAN/DME System.

- The *Standard* ALS is intended to provide segmented and multiple glide slope approaches down to at least ICAO Category II minimums. Selectable curved or segmented approach paths may be required to avoid no-fly zones for tactical or environmental reasons. This avionics configuration will include an angle receiver/processor, DME interrogator, antenna, RF front ends, display and control unit, and *interface unit* to the autopilot and indicators. The aircraft

utilizing this level of avionic equipment will be equipped with analog computation for the flight director and automatic approach systems.

- The *Advanced* version of the ALS is generally forecast by the manufacturers to be very similar to the standard version (but may be digital or hybrid), with some added logic for flare and duplicated units for redundant "fail operational" capability.

4.4.2 Installation Evaluation Approach

4.4.2.1 Establishment of Installation Parameters

Documents relating to airline procurement of an ILS system were reviewed to establish parameters pertaining to aircraft installation and integration. The context and the degree of conformity imposed on the system designer was considered, i.e., firm requirements, option selection, design goal, or suggestion and guidance. The established parameters were used to provide a typical framework that could be appropriate to an ARINC-type Characteristic or set of Characteristics for the ALS. Appendix F presents the items considered relevant to installation "requirements" for the ALS. Appendix G contains the "requirements" themselves.

4.4.2.2 Description of Candidate Systems

The design and physical attributes of the candidate microwave landing system avionics prototypes were obtained from the various suppliers. System descriptions were extrapolated into production configurations by consultations with the design engineers of the manufacturing companies involved. These "most likely" configurations for the Austere, Standard, and Advanced versions are detailed in Table 4-6. The listings of the attributes as postulated by the four competing manufacturers were not intended in any sense as proposals for avionics hardware. Equipments should not be compared; rather, a consensus may be drawn as to a likely range of parameters for the airborne hardware. Cognizant engineers were asked to extrapolate avionic units into production configurations on the basis of their experience, knowledge of the Air Force requirements, and the desire for commercial/military commonality with minimum cost impact. Equipment size and weight reductions, design for severe environments, and mounting and cooling changes are not impossible or even necessarily difficult, but they may be expensive. The postulated system descriptions can be compared with the ARINC-type Characteristic framework and with the aircraft installation constraints noted in Section 4.4.2.3.

4.4.2.3 Examination of Installation Constraints

Difficulties associated with installing the ALS in selected Air Force aircraft were examined. Three aircraft were selected: the C-141, which is projected to incorporate the Advanced version of the ALS; the F-15, expected to be equipped with the Standard version; and the A-37, for an Austere configuration. Unfortunately, insufficient data were available for the F-15 aircraft, and the F-15 was replaced with the A-7D. Limited information on the F-15, based on discussions with F-15 SPO personnel and

Table 4-6. PHYSICAL DESCRIPTION OF ALS PRODUCTION AVIONICS

Parameter	TI/Collins	Bendix	ITT Gilfillan/Honeywell	Hazeltine/Sperry
		A. AUSTERE (FAA Category I)		
Configuration & Size	Rx/Proc: 1/2 ATR(S) DME: 1/4 ATR(S) RF Head, G Band: 6 x 7 x 2 Antenna, G Band	Rx/Proc: 1/4 ATR(S) DME: 1/2 ATR(S) Antenna, G Band	Rx/Proc/DME: 1/2 ATR(S) Antenna, G Band	Rx/Proc: 3/8 ATR(S) DME: 3/8 ATR(S) Antenna, G Band
Projections	Doghouse on front	Doghouse on front	No	No
Weight	32.5 lb	21 lb	12 lb	20 lb
Environment				
Temperature	-54° to +71°C	-54° to +71°C	0 to +135°F	-50° to +55°C
Altitude	To 35,000 ft	To 45,000 ft	No restriction	To 35,000 ft
Vibration	DO-138, Cat. G (8g)	DO-138, Cat. J(3g)	10g level	DO-138, Cat. N (1g)
Shock	15/30g	15/30g	15/30g	15/30g
Mounts	Vib. Isolators (RF Head: Hard Mount)	Vib. Isolators	Hard Mount	Hard Mount
Module Extractors	Nylon Strap	Special Tool	Integral	Integ. Lever or Spec. Tool
Thermal Dissipation	65 watts	90 watts	100 to 130 watts	75 to 100 watts
Cooling	Convection	Convection	Forced Air	Forced Air w/convection opt.
Enclosure	Unpressurized	Rx/Proc: Unpress. DME: Press.	Unpressurized	Rx/Proc: Unpress. DME: May be press.
Power	115 Vac, 400 Hz, 1ø	115 Vac, 50-500 Hz, 1ø; 28 Vdc	115 Vac, 400 Hz, 1ø or 3ø	115 Vac, 400 Hz, 1ø; 28 Vdc
Connectors	Dual DPX plus TNC (front or rear)	DPX plus TNC on front	Type N (RF); otherwise not determined	Can use DPX but prefer front mount
RF Cable	Ant. to RF head - no loss Ant. to Rx/Proc (if RF head not used): ≤6 dB loss RF head to Rx/Proc: ≤120 ft of RG-214	Ant. to Rx/Proc: ≤8 dB loss (1/2" semirigid coax for run ≤75'; otherwise 3/4" semirigid coax)	Ant. to Rx/Proc: ≤4 dB (1/2" semirigid coax)	Ant. to Rx/Proc: ≤1.5 dB (36' Flexco cable)
Antennas	Horn in Radome Fwd	Horn in Radome Fwd	Horn in Radome Fwd	Blade External Fwd
		B. STANDARD (FAA Category I)		
Configuration & Size	Rx/Proc/DME: ATR(S) except width 6.5" RF Head, G Band (2): 6 x 7 x 2 RF Head, J Band: 3 x 4 x 2 Antenna, G Band (2) Antenna, J Band	Rx/Proc: 1/2 ATR(S) DME: 1/2 ATR(S) Antenna, G Band (2) Antenna, J Band Ant. Coupler, G Band	Rx/Proc/DME: 3/4 ATR(S) or 1/2 ATR(L) Antenna, G Band (2)	Rx/Proc/DME, 1/2 ATR(L) RF Head, J Band: 5 x 5 x 3 RF Head, G Band**: 6 x 4 x 2 Antenna, G Band (2) Antenna, J Band
Projections	Doghouse on front	Front projection	No	No
Weight	31 lb	28 lb	17-20 lb	23 lb
Environment				
Temperature	-54° to +71°C	-54° to +71°C	-54° to +71°C	-54° to +95°C
Altitude	0 to 35,000 ft	0 to 40,000 ft	No restriction	0 to 100,000 ft
Vibration	DO-138, Cat. G (8g)	DO-138, Cat. J (3g)	10g level	MIL-E-5400, Curve 4 (±5g)
Shock	15/30g	15/30g	15/30g	15/30g
Mounts	Vib. Isolators* except Hard-mount RF Heads	Vib. Isolators	Hard Mount	Hard Mount
Module Extractors	Nylon Strap	Separate Tool	Integral	Integ. Lever or Spec. Tool
Thermal Dissipation	120 watts	100 watts	200 watts	100 to 125 watts
Cooling	Forced Air (exc. RF Heads)	Convection	Forced Air	Forced Air w/convection opt.
Enclosure	Unpressurized	Rx/Proc: Unpress. DME: Press.	Unpressurized	Unpress., except DME Trans module may be press.
Power	115 Vac, 400 Hz, 1ø; or 28 Vdc	115 Vac, 50-500 Hz, 1ø; 28 Vdc	115 Vac, 400 Hz, 1ø or 3ø	115 Vac, 400 Hz, 1ø; 28 Vdc
Connectors	Dual DPX plus TNC's	DPX plus J Band W/G & TNC on front	Type N (RF), otherwise not determined	Can use DPX but prefer front mounted

*Hard-mount with 3g environment. **Not required for short cable runs.

Table 4-6. (continued)

Parameter	TI/Collins	Bendix	ITT Gilfillan/Honeywell	Hazeline/Sperry
B. STANDARD (FAA Category I) (Cont)				
RF Cable	Antenna to RF Head: no loss RF Head to Main Unit: ≤120 ft or RG-214 coaxial cable	Ant. to Rx/Proc: ≤8 dB (Waveguide and semirigid coax)	1/2" semirigid and RG-214 4 dB max loss	Ant. to RF Head: ≤1.5 dB (7/8" Flexco coax) 1 to 2' Flexguide for K_u RF Head to Main Unit not critical
Antennas	G&J Band Horns in Fwd Radome G Band λ/4 stub aft	G&J Band Horns in Fwd Radome G Band omni aft	Horn in Fwd Radome, λ/4 omni stub	G&J Band External Blade Fwd G Band External Blade Aft
C. ADVANCED (FAA Category I, Redundant)				
Configuration & Size	Rx/Proc/DME(2): 3/4 ATR(S) RF Head, G Band (3): 6 x 7 x 2 RF Head, J Band: 3 x 4 x 2 Antenna, G Band (3) Antenna, J Band (2)	Rx/Proc(2): 1/2 ATR(S) DME(2): 1/2 ATR(S) Antenna, G Band dir (2) Antenna, G Band omni (2) Antenna, J Band (2) Antenna Coupler (2)	Rx/Proc/DME(2): 1/2 ATR(L) Antenna, G Band dir (2) Antenna, G Band omni (2)	Rx/Proc/DME(2), 1/2 ATR(L) RF Head, J Band (2): 5 x 5 x 3 RF Head, G Band**: 6 x 4 x 2 Antenna, G Band (3) Antenna, J Band (2)
Projections	Doghouse on Front	Front Projection	No	No
Weight	70 lb	56 lb	34-40 lb	46 lb
Environment				
Temperature	-54° to +71°C	-54° to +71°C	-54° to +71°C	-54° to +95°C
Altitude	To 35,000 ft	To 40,000 ft	No restriction	To 100,000 ft
Vibration	DO-138, Cat. G (8g)*	DO-138, Cat. J (3g)	10g level	MIL-E-5400, Curve 4 (±5g)
Shock	15/30g	15/30g	15/30g	15/30g
Mounts	Vib. Isolators, except Hard-mount RF Heads*	Hard Mount	Hard Mount	Hard Mount
Module Extractors	Nylon Strap	Separate Tool	Integral	Integ. Lever or Spec. Tool
Thermal Dissipation	260 watts	200 watts	400 watts	200 to 250 watts
Cooling	Forced Air (exc. RF Heads)	Convection	Forced Air	Forced Air w/convec. opt.
Enclosure	Unpressurized	Rx/Proc: Unpress. DME: Press	Unpressurized	Unpress., except DME trans module may be pressurized
Power	115V, 400 Hz, 1Ø, or 28 Vdc	115V, 50-500 Hz, 1Ø; 28 Vdc	115V, 400 Hz, 1Ø or 3Ø	115V, 400 Hz, 1Ø; 28 Vdc
Connectors	Dual DPX plus TNC's	DPX plus J Band W/G & TNC on front	Type N for RF, otherwise not determined	Can use DPX but prefer front-mounted
RF Cable	Ants. to RF Heads no loss RF Heads to Main Units: ≤120 ft of RG-214 coax.	Ant. to Rx/Proc: ≤8 dB (W/G & semirigid coax)	1/2" semirigid coax plus RG-214 ≤4 dB loss	Ant. to RF Head: ≤1.5 dB (7/8" Flexco coax for G Band; 1' to 2' J Band Flexguide) RF Head to Main Unit not critical
Antennas	Dual G&J Band Horns in Fwd Radome; G Band λ/4 stub aft	G&J Band Horns in Fwd Radome G Band omni's aft	Dual G Band Horns in Fwd Radome Dual G Band omni's aft	Dual G&J Band External Blades Fwd Omni G Band Blade Aft

*Hard-mount with 3g environment. **Not required for short cable runs.

the USAFIT study[15] referenced previously, has been included in this report. With the resources allocated for this part of the study, it was not possible to investigate the total airframe for available space, which would have required installation design trade-offs. Therefore, the investigation was limited to the avionics bays.

4.4.3 Results of Installation Evaluation

The principal parameters of an avionics equipment as normally defined by the ARINC documents were compared with the MLS production-equipment descriptions and with the aircraft constraints expected in the selected aircraft. Comparisons were separated into "Austere", "Standard", and "Advanced" categories. The tables presented in this section provide a side-by-side listing of the comparison items for each category. Comments on areas of incompatibility are provided.

4.4.3.1 Austere ALS Configuration

As indicated in Table 4-7, space in the avionics compartment of the A-37B is extremely limited. At least one manufacturer reports that he can produce the Austere ALS in a 1/4 short ATR package; this package will fit into the existing ILS space on the A-37B.

Connectors, connector locations, and interconnection wiring must be carefully considered because of the interface required with existing aircraft elements. Of major importance in this regard is the possibility that the ALS, during the transition period from ILS to ALS, will have to be installed *in addition* to ILS equipment. Installation wiring additions to interconnect ALS equipments should be straightforward and are not considered to be a significant engineering problem, although they may represent a significant cost item. However, providing the ability to select ALS or ILS and utilize a common display will be more difficult. Other system interfaces for the Austere version, as typified by the A-37 for example, are not expected to be a problem (there are no autopilot couplers, RNAV or other computer interfaces, etc.). The major factors affecting environment are altitude, temperature, and vibration. Hardware estimates for Austere ALS units reflect possible temperature problems, but these do not appear to be severe. However, if the units require forced-air cooling, as proposed by one vendor, a special plenum/ducting installation would be needed in the A-37 to supply cooling air.

The last area of potential problems is the use of semi-rigid coaxial cable. As noted in Table 4-7, this is particularly difficult to install during retrofit programs. Special emphasis should be placed on avoiding the use of semi-rigid cable.

4.4.3.2 Standard ALS Configuration

As indicated in Table 4-8, no space is available in the avionics bays of the A-7D aircraft. The space occupied by the existing ILS on the A-7D is approximately the same as the equipment manufacturer's estimate for the ALS.

Environmental conditions represent some problems. Two manufacturers proposed altitude designs adequate for the A-7D, and another is reasonably near the requirements. One manufacturer specified an inadequate temperature range for convection-cooled equipment. The ALS vibration design criteria were referenced to sinusoidal test specifications that may not be appropriate

Table 4-7. PHYSICAL AND ENVIRONMENTAL FEATURES OF ALS AUSTERE SYSTEM

ARINC "Characteristic"*	MLS Description	Aircraft Constraints
Unit dimensions are standardized. They are related to ATR case sizes: full, 3/4, 1/2, 3/8, 1/4 ATR (short and long). Also "ELFIN" modules (inserted into 1/4 ATR case). Full ATR: 10.125" W, 7.625" H maximum, 19.5625" L (or 12.5625" for short). Fractional ATRs relate to width dimension; they are: 3/4 ATR = 7.50", 1/2 ATP = 4.875", 3/8 ATR = 3.5675", 1/4 ATR = 2.250".	Equipment Dimensions: Receiver-Processor Unit • 1/2 short ATR (TI) • 1/4 short ATR (Bendix) • 3/8 short ATR (Hazeltine) • 1/2 short ATR (ITT) - includes DME unit DME Unit • 1/4 short ATR (TI) • 1/2 short ATR (Bendix) • 3/8 short ATR (Hazeltine) RF Head - 6 × 7 × 2 (TI)	Installation Space: A-37B. Avionics space severely limited.
Connector types specified: DPA, DPX, DPD, single or dual. Standardized inserts. Pin coding required.	Connectors not yet determined. All suppliers can use DPX; desire TNC or Type N coaxial connector for RF input (one manufacturer prefers front-mounted MS).	Various connectors are used. Standardization should not be a problem.
Connector locations specified on rear of units with precise dimensioning.	Locations not yet determined (one manufacturer prefers front-mount).	Aircraft mount can be designed to a selected connector location.
Unit weight limits are related to box size (not considered binding): 1/4 short ART - 7 to 12 lbs, 3/8 short ATR - 5 to 15 lbs, 1/2 short ATR - 8 to 18 lbs.	System Weight Estimates (including DME as separate package): • TI - 32.5 lbs • Bendix - 21 lbs • Hazeltine - 20 lbs • ITT - 12 lbs	Weight should be kept to a minimum.
Interconnection wiring is specified at the unit interface with connector pin functions identified. RF cable loss and VSWR specified.	Not yet defined, except for RF cable type/loss/length. Three suppliers require 1/2" or 3/4" semi-rigid coaxial cable; one suggests RG-214 between the receiver and RF head.	Semi-rigid cable is difficult to install, particularly in retrofit.
Altitude - category may vary according to intended use.	• To 35,000 ft (TI and Hazeltine) • To 45,000 ft (Bendix) • "No restriction" (ITT)	A-37B unpressurized - expected ceiling 25,000 ft.
Temperature - category may vary according to intended use -- tied to altitude factor.	• -54° C to +71° C (TI and Bendix) • -50° C to +55° C (Hazeltine) • 0 to +135° F (ITT)	Temperature extremes extrapolated from avionics bay test area (-54° C to +78° C)
Vibration - category may vary according to intended use. Test with sinusoidal input for maximum excursion and/or g level.	• 8g maximum to 2000 Hz (TI) • 3g maximum to 2000 Hz (Bendix) • 1.5g maximum to 55 Hz, and 1.0g constant 55 Hz to 2000 Hz (Hazeltine) • 10g level (ITT)	A-37B avionics bay test levels 2g or less.
Mounting design guidance and discussion offered; clearance and sway space defined.	• Hard-mount (Hazeltine and ITT) • Vibration isolators (TI and Bendix)	All A-37B avionics in the aft bay utilize mounts.
Provisions for forced-air cooling are detailed and specified. If possible, equipment should require convection cooling only.	• Convection (TI and Bendix) • Forced air (ITT) • Forced air with convection option (Hazeltine)	Forced air not currently available. RAM air supplied to avionics bay.
Input power specified by reference to MIL-STD-704, Category 'B'. A single type of power is preferred with a single circuit breaker of specified size.	• 115 Vac, 400 Hz 1Ø (TI) • 115 Vac, 50 to 500 Hz 1Ø and 28 Vdc Bendix) • 115 Vac, 400 Hz 1Ø and 28 Vdc (Hazeltine) • 115 Vac, 400 Hz 1Ø or 3Ø (ITT)	A-37B primary power 28 Vdc (115 Vac, 400 Hz from inverter).
"Standard" control panel is usually described in detail, including form factor, connectors, functions, and lighting. Preface notes that customer may want customized panel.	Not defined.	Probable customized VOR/ILS/ALS panel at lower central instrument panel.
Display options may be described or the function alone discussed, with details left to the supplier.	Plan to use existing aircraft displays.	A-37B existing display ID-387 probably adequate.
Autopilot coupler may be described or functional requirements discussed. May require parallel outputs for integrity monitoring.	Coupler is not part of MLS. Austere version not likely to be coupled for automatic approach. No digital outputs.	No autopilot.

*Includes TSOs, RTCA Documents, ARINC Characteristics, Reports, and Specifications as normally used in commercial procurement.

Table 4-8. PHYSICAL AND ENVIRONMENTAL FEATURES OF ALS STANDARD SYSTEM		
ARINC "Characteristic"*	MLS Description	Aircraft Constraints
Unit dimensions are standardized. They are related to ATR case size: full, 3/4, 1/2, 3/8, 1/4 ATR (Short and Long). Also "ELFIN" modules (inserted into 1/4 ATR case). Full ATR: 10.125" W, 7.625" H maximum, 19.5625" L (or 12.5625" for short). Fractional ATRs relate to width dimension; they are: 3/4 ATR = 7.50", 1/2 ATR = 4.875", 3/8 ATR = 3.5675", 1/4 ATR = 2.250".	Equipment Dimensions: Receiver-Processor-DME Unit • Short ATR with width 6.5" (TI) • 3/4 short ATR or 1/2 long ATR (ITT) • 1/2 long ATR (Hazeltine) Bendix Proposes Two Units • Receiver-Processor Unit 1/2 short ATR • DME Unit 1/2 short ATR RF Head • G Band (2 each) 6 × 7 × 2 (TI) • J Band 3 × 4 × 2 (TI) • G Band 6 × 4 × 2 (Hazeltine) • J Band 5 × 5 × 3 (Hazeltine)	Installation Space, A-7D. There is *no* available space in the avionics bays. Installation Space, F-15. Extremely limited.
Connector types specified: DPX, DPA, DPD, single or dual standardized inserts. Pin coding required.	Connectors not yet determined. All suppliers can use DPX; coax input TNC or Type N; Bendix requires J Band W/G into Receiver-Processor Unit.	A-7D avionics generally have individual mounts which accommodate various connector types. F-15 equipment generally uses front-located screw-on (MS) connectors.
Connector locations specified on rear of units with precise dimensioning.	Locations not yet determined. (One manufacturer prefers front mount.) Bendix W/G probably bolted to unit front.	A-7D mounts can be designed to the selected connectors. F-15 may require special interface racks or adapters if rear mounted (DPX) connectors are used.
Unit weight limits are related to box size (not considered binding): 1/2 short ATR - 8 to 18 lbs, 3/4 short ATR - 10 to 30 lbs, 1/2 long ATR - 18 to 40 lbs.	System Weight Estimates: • TI - 31 lbs • Bendix - 28 lbs • Hazeltine - 23 lbs • ITT - 17 to 20 lbs	Weight not critical (within reasonable bounds).
Interconnection wiring is specified at the unit interface with connector pin functions identified. RF cable loss and VSWR specified.	Not yet defined, except for RF cable type/loss/length. Three suppliers require 1/2" or 3/4" semi-rigid coaxial cable; one suggests RG-214 between the receiver and RF head.	Semi-rigid cable and wave guide are difficult to install, particularly in retrofit involving high-density installations.
Altitude - category may vary according to intended use.	• To 35,000 ft (TI) • To 40,000 ft (Bendix) • To 100,000 ft (Hazeltine) • No restriction (ITT)	A-7D avionics bays are unpressurized: 0 to 45,000 feet. F-15 has pressurized compartments but altitude level not determined.
Temperature - category may vary according to intended use -- tied to altitude factor.	• -54° C to +71° C (TI, Bendix and ITT) • -54° C to +95° C (Hazeltine)	A-7D estimated range -54° C to +82° C (-54° C to +54° C if forced air cooling is used). F-15 temperature environment not determined.
Vibration - category may vary according to intended use. Test with sinusoidal input for maximum excursion and/or g level.	• 8g maximum to 2000 Hz (TI) • 3g maximum to 2000 Hz (Bendix) • 5g per curve 4, MIL-E-5400 (Hazeltine) • 10g level (ITT)	A-7D equipment specifications call out 10g level per MIL-E-5400. F-15 vibration levels up to 9.5g RMS (up to 15g RMS adjacent to RT side gun)
Mounting design guidance and discussion offered; clearance and sway space defined.	• Hard-mount (Hazeltine and ITT) • Vibration isolators (TI and Bendix)	A-7D all avionics in the avionics bays either have individual vibration mounts or are in a mounted rack. F-15 avionics are generally hard mounted.
Provisions for force-air cooling are detailed and specified. If possible, equipment should require convection cooling only.	• Convection (Bendix) • Forced air (TI & ITT) • Forced air with convection option (Hazeltine)	Both A-7D and the F-15 can supply forced-air cooling to selected equipments in the avionics bays. Air flow is the "reverse" of the ARINC standard; i.e., air is forced into the equipment rack and exits into the avionics compartment.
Input power specified by reference to MIL-STD-704, Category "B". A single type of power is preferred, with a single circuit breaker or specified size.	• 115 Vac, 400 Hz, 1Ø or 28 Vdc (TI) • 115 Vac, 50 to 500 Hz, 1Ø and 28 Vdc (Bendix) • 115 Vac, 400 Hz, 1Ø and 28 Vdc (Hazeltine) • 115 Vac, 400 Hz, 1Ø or 3Ø (ITT)	Both the A-7D and the F-15 deliver 115 Vac 400 Hz 3Ø primary power. 28 Vdc is available from TR secondary source.
'Standard' control panel is usually described in detail, including form factor, connectors, functions and lighting. Preface notes that customer may want customized panel.	Not defined.	Cockpit area is very crowded. Probable customized panel to control CNI functions along with ILS/ALS.
Display options may be described or the function alone discussed, with details left to the supplier.	Plan to use existing aircraft displays.	Current displays in both aircraft are considered adequate.
Autopilot coupler may be described or functional requirements discussed. May require parallel outputs for integrity monitoring.	Standard ALS to provide both digital and analog outputs for coupled approach and display.	A-7D autopilot can accept analog inputs but is not now coupled for automatic approaches. No interface with central computer. F-15 autopilot cannot accept landing system inputs.

*Includes TSOs, RTCA Documents, ARINC Characteristics, Reports, and Specifications as normally used in commercial procurement.

for modern jet aircraft. The vibration tests required by DO-138 (and also by MIL-E-5400P and MIL-STD-810B) relate to excursions and g levels for sinusoidal or periodic vibrations. Actual environments of jet aircraft are better described in terms of random vibration, commonly described as acceleration power spectral density across a range of vibration frequencies. Vibration test data noted as a power spectral density plot or derived as an RMS g level cannot be directly related to the sinusoidal specification levels obtained from the equipment manufacturers. Vibration environments on different aircraft types can vary significantly. For example, the excitation level provided near a Gatling-gun installation on a high-performance aircraft can be several times the excitation level in an ARINC rack on a transport-type aircraft. It is apparent that equipment designed to meet vibration levels found in airline use may not tolerate the much more severe vibration environments in the A-7D and F-15.

As with the Austere system, the use of waveguide or semi-rigid cable presents a serious problem. The difficulty of installing this cable during retrofit is aggravated for the aircraft using the standard system since these are very high-density installations. Again, special emphasis should be placed on avoiding the use of waveguide or semi-rigid cable.

4.4.3.3 Advanced Configuration - C-141 Aircraft

The Advanced version of the ALS is generally forecast by the manufacturers to be very similar to the Standard version, with some added logic for flare and duplicated units for redundant "fail operational" capability.

Units built to current ATR dimensions will fit into the C-141 avionics space without undue difficulty (see Table 4-9). It is expected that the same installation accommodation would characterize the C-5. Both aircraft are ATR-compatible. There are no substantial environmental, connection, or cooling incompatibilities in the transport-type aircraft. The only significant installation problem is the long cable run needed to connect the aft antenna with the receivers if a configuration not using separate RF heads is selected.

4.4.4 Conclusions and Recommendations

The objective of the aircraft-installation investigation was to evaluate the impact of the variation in Air Force aircraft physical and environmental differences on the feasibility of using Characteristic-type specifications and the number of such specifications that might be required.

One major constraint that will create severe installation problems in most aircraft is lack of space in avionics bays. Since there will be an extended period during which aircraft must retain existing ILS equipment, the ALS equipment in some studies has been considered an additional installation instead of substitute equipment, which further compounds the space problem. Most avionics compartments are already crowded, as are the control and display panels.

Table 4-9. ALS ADVANCED SYSTEM

ARINC "Characteristic"*	MLS Description	Aircraft Constraints
Unit dimensions are standardized. They are related to ATR case size: full, 3/4, 1/2, 3/8, 1/4 ATR (Short and Long). Also "ELFIN" modules (inserted into 1/4 ATR case). Full ATR: 10.125" W, 7.625" H maximum, 19.5625" L (or 12.5625" for short). Fractional ATRs relate to width dimension; they are: 3/4 ATR = 7.50", 1/2 ATR = 4.875", 3/8 ATR = 3.5675", 1/4 ATR = 2.250".	Equipment Dimensions: Receiver-Processor-DME Unit (2 each) • 3/4 short ATR (TI) • 1/2 long ATR (ITT and Hazeltine) Bendix Proposes Four Units: • 2 receiver-processor units • 1/2 short ATR • 2 DME units, 1/2 short ATR RF Head • G Band (3 each) 6 × 7 × 2 (TI) • J Band (2 each) 3 × 4 × 2 (TI) • G Band 6 × 4 × 2 (Hazeltine) • J Band (2 each) 5 × 5 × 3 (Hazeltine)	Installation space, C-141A. Avionics space is limited; however, current AWLS will soon be updated with new ILS equipment, which will make some room available. Standard ATR dimensions will fit racking.
Connector types specified: DPA, DPX, DPD, single or dual. Standardized inserts. Pin coding required.	Connectors not yet determined. All suppliers can use DPX; desire TNC or Type N coaxial connector for RF input (one manufacturer prefers front-mounted MS).	C-141A avionics generally conform to ARINC Characteristics with rear-mounted rack-and-panel connectors.
Connector locations specified on rear of units with precise dimensioning.	Locations not yet determined. (One manufacturer prefers front mount.) Bendix W/G probably bolted to front of units.	C-141A installation could accommodate selected connectors. ARINC configuration is preferred.
Unit weight limits are related to box size (not considered binding): 1/4 short ATR - 7 to 12 lbs, 3/8 short ATR - 5 to 15 lbs, 1/2 short ATR - 8 to 18 lbs.	System Weight Estimates: • TI - 70 lbs • Bendix - 56 lbs • Hazeltine - 46 lbs • ITT - 34 to 40 lbs	Weight not considered critical in the C-141A installation.
Interconnection wiring is specified at the unit interface with connector pin functions identified. RF cable loss and VSWR specified.	Not yet defined, except for RF cable type/loss/length. Three suppliers require 1/2" or 3/4" semi-rigid coaxial cable; one suggests RG-214 between the receiver and RF head.	Long cable runs from the belly-mounted omni antennas will make low-loss requirements hard to achieve.
Altitude - category may vary according to intended use.	• To 35,000 ft (TI) • To 40,000 ft (Bendix) • To 100,000 ft (Hazeltine) • No restrictions (ITT)	C-141A avionics bays are pressurized to cabin altitude: 0 to 8000 ft. Antennas and RF heads could be in an unpressurized area: 0 to 45,000 ft.
Temperature - category may vary according to intended use -- tied to altitude factor.	• -54° C to +71° C (TI, Bendix and ITT) • -54° C to +95° C (Hazeltine)	C-414 ECS will maintain cabin at +24° C. Avionics temperature extremes will be due to local weather OAT at start-up, estimated -40° C to +50° C.
Vibration - category may vary according to intended use. Test with sinusoidal input for maximum excursion and/or g level.	• 8g maximum to 2000 Hz (TI) • 3g maximum to 2000 Hz (Bendix) • 5g per curve 4, MIL-E-5400 (Hazeltine) • 10g level (ITT)	C-141 test vibration levels up to 5g RMS for take-off/go-around conditions.
Mounting design guidance and discussion offered; clearance and sway space defined.	• Hard-mount (Hazeltine and ITT) • Vibration isolators (TI and Bendix)	Most of the C-141A avionics equipments have individual mounts in airline-type racks.
Provisions for forced-air cooling are detailed and specified. If possible, equipment should require convection cooling only.	• Convection (Bendix) • Forced air (TI and ITT) • Forced air with convection option (Hazeltine)	The C-141A can supply forced cooling air per ARINC specification.
Input power specified by reference to MIL-STD-704, Category 'B'. A single type of power is preferred, with a single circuit breaker or specified size.	• 115 Vac 400 Hz 1Ø (TI) • 115 Vac 50 to 500 Hz 1Ø and 28 Vdc (Bendix) • 115 Vac 400 Hz 1Ø and 28 Vdc (Hazeltine) • 115 Vac 400 Hz 1Ø on 3Ø (ITT)	The C-141A delivers 115 Vac 400 Hz 3Ø primary power, with 28 Vdc available from TR secondary source.
"Standard" control panel is usually described in detail, including form factor, connectors, functions, and lighting. Preface notes that customer may want customized panel.	Not defined.	Console space limited. Probable custom ILS/ALS control panel.
Display options may be described or the function alone discussed, with details left to the supplier.	Not defined -- manufacturers expect to use existing displays.	Use existing ADI; the C-141 may need additional plan position or chart display for curved/angled approach option.
Autopilot coupler may be described or functional requirements discussed. May require parallel outputs for integrity monitoring.	Advanced ALS to provide redundant analog and digital outputs for "fail-operational" capability.	C-141A autopilot accepts analog inputs for coupled approaches with the current AWLS. Related logic is supplied by special-purpose computers. Annunciator panel for monitor and self-test results.

*Includes TSOs, RTCA Documents, ARINC Characteristics, Reports, and Specifications as normally used in commercial procurement.

An additional major concern, and possibly a constraint, will be the aircraft modifications necessary to accept the ALS equipment. Some of the equipment manufacturers are suggesting the use of long runs of semi-rigid coaxial cable or waveguide, or both. In cases where the aircraft will have the capability of autopilot-coupled approaches, there must be an additional interface box to the flight control system. Providing the existing aircraft fleet with an ALS capability presents a formidable problem in racking, cabling, and special-purpose interfaces. Providing new aircraft with an ALS capability during production will be much less difficult.

It is recognized that the increased capability offered by the ALS is highly desirable for certain Air Force missions, particularly in a combat environment, and that compatibility with future commercial systems is desirable. However, because of the potentially high installation costs, the following alternatives should be seriously considered:

- Retain existing ILS equipment in most Air Force aircraft until most ALS ground stations are operational, and then replace the current ILS with new ALS equipment. This concept would require maintaining existing ILS ground systems along with the newly installed ALS equipment until the ILS replacement program was completed. During the interval prior to the switch-over, dual capability could be accommodated in selected large cargo and transport aircraft. However, it is unlikely that the civil ILS replacement program will be totally complete in the foreseeable future. Since many Air Force aircraft must be capable of operating into civilian airports, the following alternative is considered to be more realistic.
- Proceed with add-on approach, in which case the problem of locating or creating a space for the ALS must be addressed for each aircraft type. Solving the location problems, and the related cabling, display switching, and antenna location problems will be costly for many aircraft. Therefore, major emphasis must be placed on miniaturizing the equipment; the smaller the equipment, the more choices for location. Previous studies have shown installation cost to be a major life-cycle-cost element in a similar program.[5] An ARINC type Characteristic could be written to accommodate the most difficult (smallest) requirement. The equipment boxes, then, could be made to fit all installations. It must be noted, however, that achieving such interchangeability between all USAF aircraft would preclude interchangeability with airline and civilian equipments, at the "black box" level, unless the commercial equipments also deviated from the standard ATR dimensions (an unlikely prospect). Selected large cargo aircraft could use the ALS Characteristic specification for the Advanced ALS, which will apply to air-carrier aircraft.

Regardless of which option is selected, configurations for the three types of ALS differ to the extent that standardized dimensions and interfaces cannot be obtained. Therefore, three characteristics will be needed -- one each for Advanced, Standard, and Austere systems. If the second

option is selected, consideration should be given to using the miniature Standard ALS in Austere applications as well. This would permit interchangeability across additional aircraft types and could have life-cycle cost benefits.

The Advanced-version Characteristic can be very similar or identical to the airline version.

The Standard Characteristics must reflect the more stringent altitude, temperature, and vibration environments of the military aircraft. In general, however, the environmental requirements should be carefully researched and should not reflect the extremes of special-purpose aircraft such as the SR-71. Rather, they should reflect the limits that will meet a large majority of aircraft needs, leaving special-purpose aircraft to acquire special (nonstandard) equipment.

The Austere version of an ARINC-type Characteristic should closely match the industry design for low-cost, limited-capability, Category D equipment intended for general-aviation use. Dimensions, connectors, and interface cabling should be made standard and interchangeable with the civilian version.

In this investigation, only one aircraft was selected to represent each of the ALS installation configurations for the installation-compatibility study. In these aircraft, only the avionics area was examined for availability of ALS avionics space. Before the Characteristics discussed above can be developed, every USAF airframe candidate for ALS installation must be examined painstakingly to determine the space availability and system compatibility requirements unique to each configuration.

CHAPTER FIVE

RECOMMENDED APPROACH TO ALS SPECIFICATION DEVELOPMENT

5.1 INTRODUCTION

On the basis of the review of the commercial avionics-acquisition process and, the comparison of the military equivalent, a "straw man" specification development was prepared. The elements of the process were selected to create the climate for achieving the principal benefits of the airline process -- i.e., establishment of form-fit-function specifications with a broad base of inputs from users and suppliers -- for encouraging the availability of high-quality, low-cost equipment.

The recommendations presented in this chapter go beyond the development of a Characteristic-like specification. They can significantly increase the opportunity for cost benefit and are interrelated with the specification development process. They also serve to create a continuing opportunity for the development of a suitable group of sources from which ALS avionics can be competitively procured on an off-the-shelf basis to the Air Force's best advantage.

The process is offered as a "straw man" with the recognition that some variations will be necessary as the process is implemented and experience in parallel programs identifies more effective variations. These recommendations, therefore, represent a point of departure from which the Air Force can continue to develop the tools needed to meet the demands of national defense with decreasing budgets and buying power.

5.2 ALS SPECIFICATION DEVELOPMENT COMMITTEE

5.2.1 Structure

An ALS Specification Development Committee is recommended as the mechanism to permit the Air Force to include the commercial community in its decision-making base. Such a committee will be required to comply with the provisions of the Federal Advisory Committee Act (Public Law 92-463, 6 October 1972). It is expected that this committee will consist of voting members from the technical elements of appropriate Commands; nonvoting members, including a secretariat, a legal staff member, and selected airline, avionics, and industry representatives (such as ATA,

AEEC, GAMA, AOPA, NBAA); and representation from the FAA, Army, Navy, and DoD. Since the meetings must be open and public (as required by law) and industry has expressed interest in participation, the basis for productive dialogue will be established.

5.2.1.1 Chairman

The Chairman is the most important element in the success of the committee operation. This position should be filled, preferably, by a candidate with a technical background in aircraft navigation aids and instrument landing systems who is known and respected by the aviation community. More important, he should have experience in chairing and guiding committee activity and have a demonstrated ability to bring divergent opinions together. He should also have a permanent (although perhaps only part-time) commitment to the committee.

5.2.1.2 Director

The Committee Director may or may not be the same individual as the Chairman. The Director, however, should be a member of the TRACALS SPO so that the proper guidance and coordination can be maintained. He should also have a permanent assignment during the life of the program to assure continuity of effort. If he is not the Chairman, he should be the designated government representative without whose presence the meeting could not convene. He and the Chairman must communicate effectively to assure productive results. The Director is responsible for seeing that all the mechanical functions supporting the committee are properly executed -- e.g., maintain official committee files and records, assure that meeting facilities are available, be responsible for the administrative aspects of committee operation -- and for serving as a general coordination focal point for committee activities.

5.2.1.3 Voting Members

Committee voting members should be the most technically knowledgeable from the various Air Force Command structures. Rank should not necessarily dictate selection. Military and civil service personnel should be considered, and membership stability is paramount. Experience with all phases of aircraft navigation and landing system design, operation, and support is a primary attribute of the voting members. These members would be committed to the committee only on a part-time basis, in much the same way as the airline representatives on the AEEC.

5.2.1.4 Nonvoting Members

Nonvoting members are also expected to participate on a permanent-assignment part-time basis to assure continuity in their relationships with associated military services, government agencies, and the airline industry. A Secretariat will carry out the mechanics of recording the meeting results; preparing drafts and technical data; establishing agenda; coordinating information exchange between the industrial community and the

Air Force; and, in coordination with the Committee Director and Chairman, arranging for timely meeting schedules and meeting agenda items. The Secretariat should be composed of two or three full-time permanent members responsible for the technical writing associated with specification drafts and revisions. Each of the Secretariat members should have a background and detailed technical understanding of aircraft navigation and landing systems, as well as experience in technical writing.

5.2.2 Operating Method

Essentially, the Director has responsibility for administrative matters; the Secretariat has the responsibility for technical matters; and the Chairman guides the course of the meetings, maintains the pace to assure progress, and acts as a catalyst for compromise where conflict arises.

5.2.2.1 Stability/Continuity

One aspect of the committee operation that has been emphasized throughout the preceding paragraphs is important enough and has sufficient problem potential that further elaboration is appropriate. Stability of membership must be a consideration of utmost priority. The success of the equivalent activity in the commercial aviation community is strongly related to the relationships between the individuals involved. Productive discussion of controversial topics requires that the participants understand and tolerate each other's personality and approach. Openness and understanding are one result of the familiarity of a continued relationship. Continuity in understanding of the technical evolution of the system and the changes in system requirements is another important factor. Specification development will progress concurrently with equipment adaptation (the manufacturer in the airline industry adapts his equipment during the interchange with the potential customer so that his product will have what he believes to be the competitive edge when procurements occur). Knowledge on the part of the participants regarding the mistakes and changes in the past, as specification development progresses, minimizes "reinventing the wheel".

5.2.2.2 Procedural Considerations

In order to comply with the Advisory Committee Act, the ALS Specification Development Committee must renew its charter every two years. In addition, certain operational requirements are imposed, for example:

- A charter must be developed and approval obtained from the OMB Secretariat; the charter must be published in the Federal Register and then filed.
- Meetings must be called in advance with wide public notice, including publication 15 days in advance in the Federal Register. The notice must include the meeting agenda to permit attendance by interested parties. Public participation should be encouraged to the greatest extent by providing meeting places and times to maximize the accommodation of all interested parties.

- Members of the public are permitted to file written statements with the committee and, at the option of the Chairman, to make statements.
- Minutes of the meetings are required. However, no stenographic transcript is required.
- A designated Federal employee must attend the committee meetings. He can be the Chairman or the Director. The meetings are not permitted unless this permanently designated Federal representative is present.

As much informality as possible is encouraged, consistent with orderly operation, to assure openness and candor. Achievement of such a climate depends largely on the personnel selected -- the reason for the previous emphasis on the personnel qualifications.

5.2.3 Timing

The interval between meetings is an important factor. In the airlines, the attendees (with the exception of the Secretariat) all have job responsibilities outside the committee activities. They review the committee documents, formulate their comments, and return them to the Secretariat between the normal demands of their work. Meetings must be timed, then, so that the previous meeting's results can be incorporated into the drafts of the specifications, distributed to the participants for review and comment, and returned to the Secretariat for consolidation, publication, and redistribution so that all participants will have the benefit of the others comments before the next meeting (which must be announced in the Federal Register 15 days before it occurs).

Such a sequence suggests that the Committee meetings occur at a minimum interval of two months and a maximum interval of six months. The longer interval would be associated with subcommittee activity in which supportive or subordinate specifications or parts of an overall specification were handled separately and brought before the full committee when complete. These subcommittees could meet more frequently (probably every two months). The coordination process must be completed in the minimum interval, and the maximum interval should be short enough for interest to be maintained.

5.3 SPECIFICATION DEVELOPMENT

5.3.1 Basic Assumptions

The ultimate application of the specifications influences their overall content. This is the major reason for separating the specifications into parts reflecting the constants of technical performance and the variables of procurement. They cannot be considered separately from the procurement itself. To place the primary and supplemental specifications and supporting documents in perspective, the ALS equipment procurements are considered to be fixed-price production procurements, each for a limited quantity and each competitive. The process recommended considers that an initial

long-term (2 to 5 years) warranty will be used to demonstrate equipment compliance with operational requirements, with subsequent options for warranty renewal or contract maintenance. Other alternatives may be considered as the specifications develop in committee and as experience with other related programs provides data for quantitative assessment without negating the value of expeditiously implementing the approach presented herein.

5.3.2 Initial Approach

As a matter of convenience, at least at the outset of the process, ARINC Characteristics should be used as "straw man" documents, particularly Characteristic 578 and supplemental Characteristics. For the Advanced ALS configuration, to be applied in transport aircraft, the greatest degree of compatibility should be maintained between the ARINC Characteristic and the TRACALS ALS Specification so that the Air Force can benefit from a combined commercial/military competitive market. (This compatibility should be enhanced through assignment of a TRACALS ALS Committee member to the AEEC Subcommittee on MLS when it forms.)

Similarly, development of an Austere configuration, which would serve as the basic design for General Aviation use in business aircraft, could be served by the inclusion of General Aviation representation on the Committee. Creation of a low-cost equipment design to satisfy Air Force and civil requirements would bring to the relatively small Air Force procurement the advantage of quantity purchases. The General Aviation market represents more than 20,000* turbojet, turboprop, and medium-to-heavy piston-engine aircraft that require reliable low-cost equipment with basic (minimum) performance capabilities.

5.3.3 Form, Fit, and Function

Form, fit, and function interchangeability between equipments and their subordinate elements manufactured by different suppliers requires that some aspects of current military specifications be substantially deemphasized and other portions emphasized. Wherever possible, requirements that describe *what* the Air Force desires should be retained and those which describe *how* it is to be produced should be eliminated.[14]

5.3.4 Justification of Features

Requirements should be justified on the basis of their cost impact, and the specification should contain the reason for including each principal feature. Where features do not represent a consensus, the alternatives and reasons should be presented.[25] In this way, the factors influencing the manufacturer's design are recorded for the user and seller alike, with cost considerations countering the tendency toward overdesign and the rationale for a particular feature countering the tendency toward underdesign. Each competitor will attempt to optimize his design between these bounds.

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*From current FAA/AOPA figures.

5.4 SUPPLEMENTARY DOCUMENTATION

Wholesale invocation of specifications and data requirements through reference to MIL-E-5400, MIL-STD-454, and Military Bulletin 400 (under MIL-STD-490 Type C2a) should be eliminated from the equipment specification, statement of work, and contract data requirements. An evaluation of every specification or requirement should be conducted, again with emphasis on retaining those items which relate to *what* is required rather than *how* it is to be provided. Specifications establishing extensive reporting or control requirements should be carefully evaluated in terms of the cost to the manufacturer, the cost to the government (including the personnel and facilities needed to manage, acquire, analyze, store, and distribute), the benefits derived from similar data on other contracts, and the alternatives if the data are *not* acquired. The existing procedure for justifying data element acquisition (AFSC Form 40) addresses this problem. If it is effectively minimizing present data requirements, its use in the proposed procurement procedure should be continued.

5.5 SCHEDULE

The recommended process should be implemented in correlation with the schedules projected in the TRACALS ALS Program Management Plan (see Figure 5-1). This plan is aligned to coincide with the FAA MLS Program Plan. So that the Committee development process can be initiated within a time frame that will permit implementation of the procurement according to the AF/FAA schedule, the committee should be prepared to convene its first session in the first quarter of CY 1975.

For the initial meeting to occur at that time, several important steps must be taken:

1. Develop an initial Committee membership list of candidate personnel from which the TRACALS SPO can select.
2. Develop and submit an ALS Committee Charter for approval; follow up to assure timely review.
3. Select Committee members and obtain commitments for their participation.
4. Prepare for initial meeting:
   - Agenda/Schedule
   - Federal register publication
   - Meeting facilities and support
   - Facilities for attendees
   - Follow-up mechanics

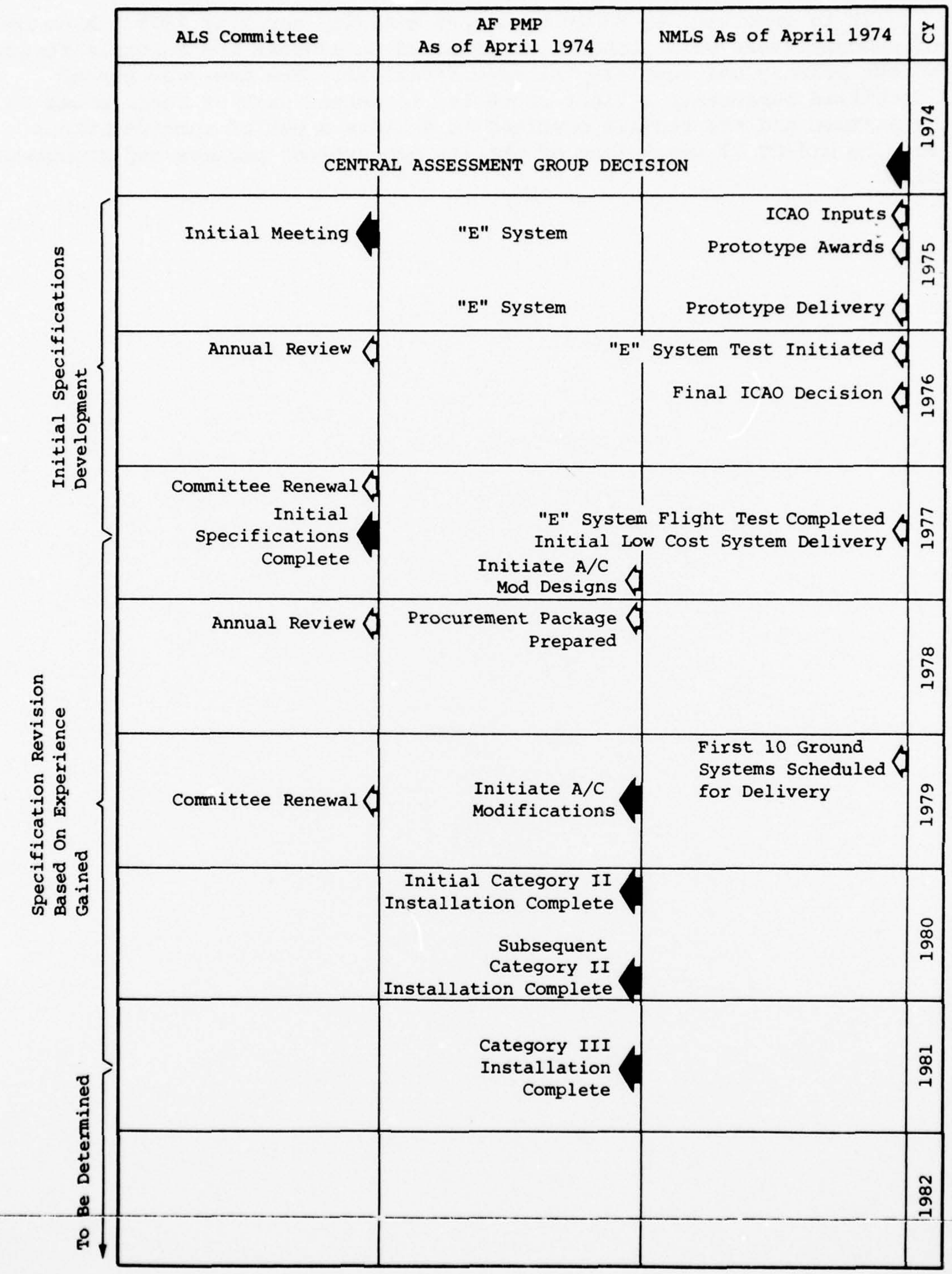

Figure 5-1. SCHEDULES

It is important to begin committee activity early in 1975. A number of subcommittees will probably be required to address the multiple facets of the primary and supplemental specifications. The two-year period identified represents a tight schedule to permit each of these areas to be pursued and the results combined to achieve a set of specifications for the mid-CY 77 completion of the ALS procurement package and procurement plan.

CHAPTER SIX

CONCLUSIONS

A number of conclusions were derived from this study of the feasibility and the possible cost benefits of developing ARINC Characteristic-type specifications for a future Advanced Landing System (ALS) avionics procurement. In reaching these conclusions, we made two major assumptions:

1. All development will have been completed, and only production procurement of off-the-shelf equipment will be involved.
2. Full-life warranty (contractor support) will be used instead of Air Force organic maintenance. (This assumption does not preclude use of a mix of warranty and organic support, or full organic support at the time of procurement. Adequate data are not currently available, however, to justify any of the support alternatives at this time. The decision is not critical to implementation of the process at this time.)

The conclusions are as follows:

- Indisputable data on cost and reliability comparisons of military versus commercial airline avionic equipment are not available. Nevertheless, the total weight of available data clearly supports the experimental application of selected airline avionics acquisition practices (including development and application of Characteristic-type specifications) to the ALS program.
- There are no insurmountable formal barriers to Air Force use of airline specification development or application practices. In an organization the size of the Air Force, however, human resistance to change is seen as the largest obstacle to the success of even an experimental application of airline practices.
- Space availability represents a major installation problem in other than some transport aircraft. The ALS avionics/automatic-flight-control-system interface represents another major installation problem in those configurations requiring coupled approach and landing capabilities. Similarly, concurrent installation of ILS and ALS avionics will present a space problem in many aircraft types regardless of the standardization approach taken. To provide sufficient information upon which the committee responsible for

characteristic development can base its size-cost-performance tradeoffs, a thorough space-availability and system-compatibility study of every anticipated USAF ALS installation must be performed.

- Environmental factors (vibration, temperature, and altitude) will require special installation considerations in high-performance aircraft. Overall cost-benefit considerations beyond the scope of this study may dictate nonstandard equipment for such limited-quantity, high-performance applications.
- Three separate Characteristic-type specifications are considered necessary -- one each for the Austere, Standard, and Advanced ALS avionics. The Advanced system requirements should be so similar to airline needs that separate development of a Characteristic by the Air Force would not be required. Suitable ancillary documents for procurement would, however, be necessary if an airline-developed specification was used.
- The number of military standards and specifications normally referenced in military procurements can be substantially reduced if an ARINC-type Characteristic and associated procurement practices are used. The major reduction in standards and specifications is associated with elimination of design, parts, and process control.
- A major reduction in contractor data requirements can be achieved if the overall acquisition approach associated with the use of ARINC Characteristics is followed. Data-requirements reductions are also related to elimination of detailed equipment design and production control.
- Staffing of the committee charged with developing the Characteristics will require careful consideration of capabilities as well as continuity. The importance of these personnel selections should not be underestimated.
- Despite uncertainties and anticipated problems, no impossible barriers are evident, and thus the application of ARINC-type Characteristics and associated procurement practices is concluded to be feasible. Potential cost-benefit advantages as stated in the first conclusion clearly support, at the very least, the experimental application of the approach as an aid to future Air Force and DoD decision-making on improving procurement practices.

APPENDIX A

TASK EFFORTS

This appendix presents a description of the tasks as they appear in the Work Statement, with brief summaries of the effort associated with each task. The overall contract effort is defined as follows:

> "Investigate the feasibility and cost effectiveness of applying ARINC Characteristic type specifications to the procurement of Austere, Standard, and Advanced avionics configurations for the USAF Advanced Landing System (ALS)."

1. TASK 1

1.1 Task Statement

"Examine current USAF and DoD procurement directives for restrictive or prohibitive language concerning the development process and utilization of an ARINC Characteristic-type specification. Evaluate the procurement significance of any identified conflicts and make conflict resolution recommendations to the DoD AIMS/TRACALS SPO."

1.2 Summary of Effort

To execute Task 1, we identified the AEEC Characteristic development process and airline procurement practices and developed an alternative. We made an initial comparison with the Military Specification development process and procurement practices. We then reviewed the ASPR, DoD, AF, and AFSC directives, and other documents that appeared to be germane to an initially assumed procedure, and discussed elements of the procedure with ESD procurement personnel. Where appropriate, we modified the procedure and held further discussions with ESD and AFSC HQ procurement personnel to review the process considerations again. We held discussions with various military and airline community (user and manufacturer) personnel to verify procedural steps and consulted the ARINC Research Director of Contracts and the AEEC Chairman.

2. TASK 2

2.1 Task Statement

"Investigate similar applications of ARINC Characteristics, including those used for procurement of ILS avionics, and ascertain the impact of the Characteristic on equipment performance, quality, and cost. Include an appraisal of the requirement for and use of ancillary procurement documents such as RTCA Minimum Performance Standards, Manufacturers equipment specifications, etc."

2.2 Summary of Effort

We reviewed the airline procurement procedure and typical contracts, including the ARINC Characteristic development as it related to the procurement process. We identified reference documents invoked by the ARINC Characteristic as well as additional contractual elements necessary to the purchase of ILS avionics. This included such items as Characteristics 568 and 578; ARINC Specification 404 and 410; ATA Specifications 100, 101, 200, and 300; FAA TSOs (and RTCA Standards referenced); and manufacturers' handbooks and the contract statements relating to reliability, warranties, training, and documentation. In addition, we met with various air transport industry personnel to confirm procedures and experience. We acquired data to permit a limited assessment of equipment performance, quality, and cost. The measure of performance was the degree of compliance with RTCA Standards; the measure of quality was related to unscheduled equipment removals, and cost was based on manufacturers' advertised prices.

3. TASK 3

3.1 Task Statement

"Identify and evaluate potential significant installation problems that could be a deterrent to the formulation of ARINC Characteristics for the procurement of Austere (Category I), Standard (Category II) and Advanced (Category III) ALS avionics as applicable to the various classes of aircraft in the USAF inventory. Include consideration of potential interface problems with existing aircraft interwiring, autopilot couplers, autopilots, on-board computers, cockpit instrumentation, etc. Also determine if, where, and why more than one ARINC Characteristic will (or may) be required to cover the full range of anticipated ALS avionics applications."

3.2 Summary of Effort

Three aircraft were initially identified as the host vehicles for the three ALS configurations that would be used as examples for the evaluation: A-37, C-141, and F-15. Difficulty in obtaining adequate F-15 data resulted in the substitution of the A-7 for that equipment category.

We reviewed appropriate documentation and data, including the AFIT MLS Study, ARINC Characteristic 578 (and associated references), and aircraft configuration data. We visited the organizations responsible for each aircraft type, the manufacturers of the MLS avionics currently under evaluation by the FAA, and AFLC item managers for various aircraft equipment to establish equipment configuration details for the evaluations.

From the data acquired, we evaluated the range of interface problems and documented them in qualitative terms. We considered them further with regard to their relationship to AEEC form, fit, and function factors and the number of principal AEEC Characteristic-type specifications identified as peculiar to the possible configurations.

4. TASK 4

4.1 Task Statement

"Identify, and evaluate the impact of, MIL-SPEC provisions that will have to be retained in the ALS Characteristic(s) to ensure that equipment performance and quality goals are met. Also review typical data requirements and identify the minimal data items required for effective management and control of the program. Utilize the outputs of the above investigations as applicable in determining the feasibility of purchasing commercial grade avionics."

4.2 Summary of Effort

We selected the AN/ARN-XXX as the system example for identifying the MIL-SPEC provisions associated with an equipment procurement. The AN/ARN-XXX is an ILS-similar avionic system and represents an example of extensive MIL-SPEC call-outs and data-item requirements. We reviewed the Air Force specification development and procurement process and discussed the requirements for the various data items with ESD and AFLC personnel. The requirements were considered in relationship to the airlines' procurement practices and the AEEC Characteristic and supporting documentation. We developed a list of MIL-SPEC and DD 1423 items consistent with the procurement process.

As an adjunct to the effort in Task 2, we used available data to identify the cost, quality, and performance information for Air Force ILS equipment with capability equivalent to that of airline equipment. We used this information as one of the elements in developing approximations to a "cost-effectiveness" comparison of military and airline equipment.

5. TASK 5

5.1 Task Statement

"Provide technical support to the SPO in meetings with other Air Force and/or other military/civil agencies participating in the development of a

standard national and international microwave landing system, which the ALS program supports and supplements."

5.2 Summary of Effort

Task 5 involved ARINC Research in visits and participation in various meetings. We attended the MLS Advisory Committee Meeting, AEEC General Meeting, and MLS Central Assessment Group Meetings.

6. TASK 6

6.1 Task Statement

"Provide technical support to the SPO in monitoring and evaluating the ALS avionics planning/development/specification efforts of the FAA NMLS system contractors. Also establish and maintain technical dialogue and liaison with other qualified avionics equipment contractors who might become alternate sources for ALS avionics during the production phase of the program."

6.2 Summary of Effort

Our effort in Task 6 was similar to the support provided in Task 5. We visited the MLS test sites at Wallops Island Virginia and NAFEC, as well as various MLS manufacturers.

APPENDIX B

AIRLINE PROCUREMENT DOCUMENTATION AND REFERENCES

This appendix presents salient features of ARINC Characteristic 578-3, for the Airborne ILS Receiver, with reference documents cited in the Characteristic, FAA certification requirements,and RTCA performance standards.

AD-A051 876 ARINC RESEARCH CORP ANNAPOLIS MD F/G 17/7
ADAPTABILITY OF AIRLINE-TYPE AVIONICS ACQUISITION PROCESSES TO --ETC(U)
OCT 74 W SCHULZ, M BURGESS, G BORING F09603-73-A-4392
UNCLASSIFIED 1054-01-1-1329 NL

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APPENDIX B-1

ARINC CHARACTERISTIC 578-3
AIRBORNE ILS RECEIVER

PARAMETER CALL OUT	PERFORMANCE CHARACTERISTICS	ADDITIONAL REFERENCE REQUIRED
Localizer Receiver		
	- Frequency-Range of Operation	
	- Frequency-Channeling	
	- Frequency-Selection System	ARINC Spec 410
	- Frequency-Channeling Time	
	- Sensitivity in Aural Reception	
	- Sensitivity in ILS Signal Reception	
	- Selectivity	ICAO Annex 10, RTCA Document DO131
	- Spurious Response	
	- Cross Modulation	
	- Adjacent Channel Performance (On Channel Signal Present)	
	- Performance in Presence of VHF Communications Transmissions	
	- Automatic Gain Control	
	- Desensitization and Interference Rejection	
	- Audio Output	
	Gain	
	Output Variation with Load Impedance	
	Frequency Response	
	Harmonic Distortion	
	Service Adjustment	
Glide Slope Receiver		
	- Frequency Range of Operation	
	- Frequency Channeling	
	- Frequency Selection System	
	- Sensitivity	ICAO Annex 10, RTCA Document DO132
	- Selectivity	
	- Spurious Response	
	- Cross Modulation	

- Automatic Gain Control	
- Desensitization & Interference Rejection	
ILS Equipment Drives	
- Automatic Flight Control System Outputs	
- High Level Instrumentation Outputs	
- Low Level Instrumentation Outputs	
- Deviation Output Polarity	
- Deviation Output Interface Standards	
- Localizer Course Deviation Output Linearity	RTCA DO131
- Glide Slope Course Deviation Output Linearity	RTCA DO132
- Localizer Course Centering Stability	RTCA DO131
- Glide Slope Course Centering Stability	RTCA DO132
- Automatic Flight Control System Warning Signals	ARINC Spec. 410
- High Level Instrument Warnings	
- Low Level Instrument Warnings	
- Glide Slope Deviation Bar and Flag Biasing	
ILS Monitoring Requirements	
- Input Signal Monitoring	
- Localizer Failure Monitoring	
- Glide Slope Failure Monitoring	
- Monitor Integrity	
- Monitor Sensitivity	ARINC Spec. 410
Deviation and Instrument Warning Signal Switching	ARINC Spec. 410
Audio Signal Switching	

INTERCHANGEABILITY REQUIREMENTS

CALL OUT	REFERENCE
Receiver	
- Form (And Tolerances)	ARINC Specification 404
- Connectors	
- Hold Downs	ARINC and Report No. 414
- Projections	
- Extractors	
- Cooling	
- Interface Wiring	
Control Panel	
- Configuration	Attachment 3, ARINC Report 306
- Connectors	
- Frequency Selection Method	Attachment 2, 3 and 4
- On/Off Control	
- Other Controls	ARINC Characteristic 568
- Integral Lighting	
- Interface Wiring	
Power Circuitry	
- Primary Power Input	
- Power Control Circuitry	
- Common Ground Restrictions	
- AC Common Cold Limitations	
Antenna	
- Frequency Requirements	
- Radiation Pattern Considerations	
- Transmission Line Considerations	ARINC Report No. 306

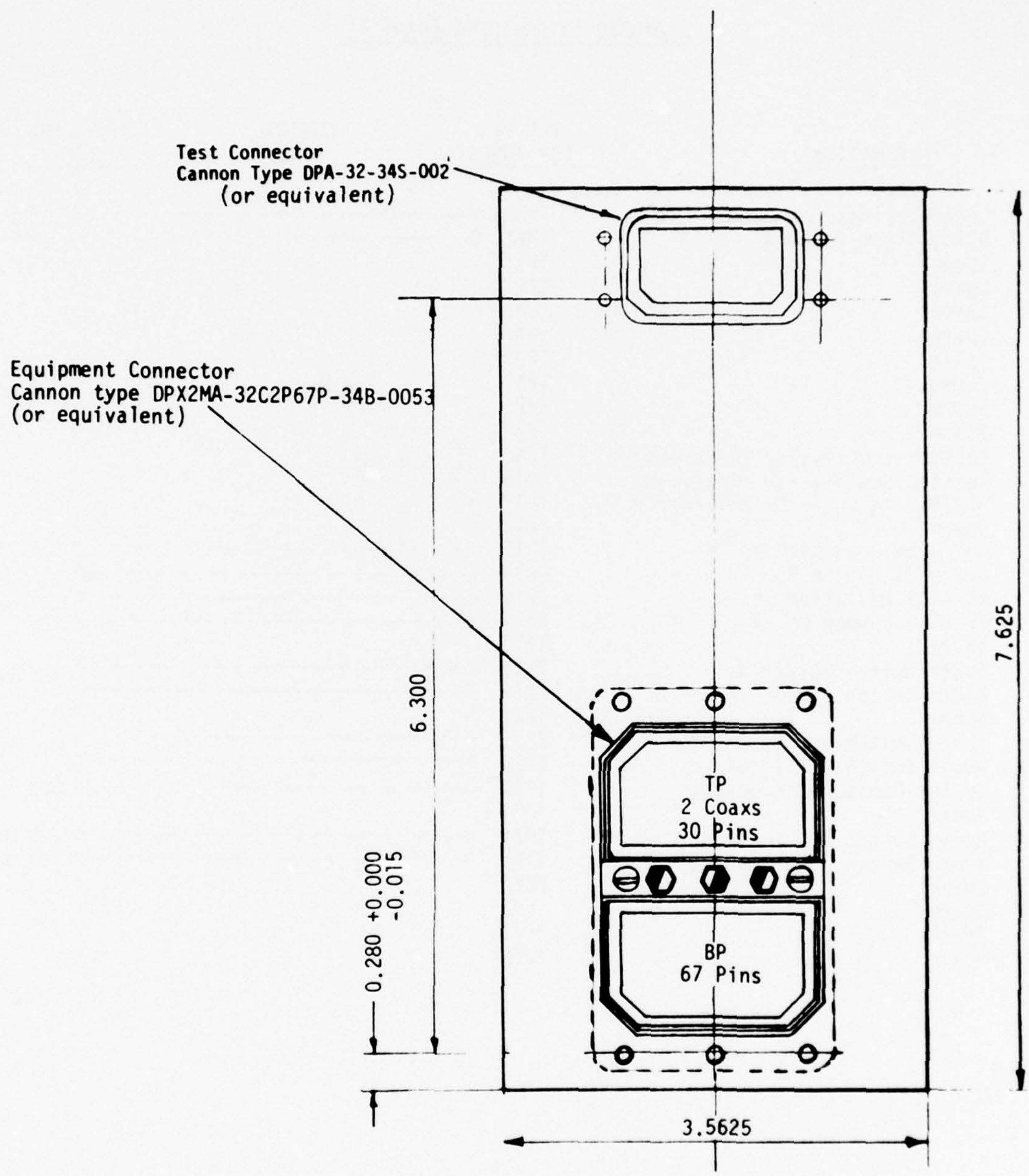
INTERCHANGEABILITY REQUIREMENTS

CALL OUT	REFERENCE
Interwiring	ICAO Annex 10, Vol 1 ARINC Specification 410 ARINC Report No. 414
Automatic Test Equipment - Connections - Unit Identification - Pin Allocation	Attachment 1

ATTACHMENT I

ARINC CHARACTERISTIC NO. 578

RECEIVER UNIT CONNECTOR POSITIONING



NOTE: Case dimensions, hold-downs and other details relating to racking are given in ARINC Specification No. 404. Details relating specifically to the DPX connectors are given in revised Supplement No. 2 to ARINC Specification No. 404 dated April 16, 1967.

ATTACHMENT 2

ARINC CHARACTERISTIC NO. 578

STANDARD INTERWIRING (PART 1)

FUNCTION	ILS RX. TOP INSERT	CONTROL PANEL	JUNCTION BOX	
Localizer Antenna	TPA1			Antennas
Glide Slope Antenna	TPA2			Antennas
Spare	TP1			
Spare	TP2			
Spare	TP3			
Spare	TP4			
Spare	TP5			
Spare	TP6			
Spare	TP7			
Spare	TP8			
Monitor Sensitivity (Reserved)	TP9	See Note 1		
Monitor Sensitivity (Reserved)	TP10	See Note 1		
¢-2 Monitor Sensitivity (Reserved)	TP11	See Note 1		
Spare	TP12			
LOC AFCS Deviation No. 1	TP13		o	
LOC AFCS Common No. 1	TP14		o	
GS AFCS Deviation No. 1	TP15		o	
GS AFCS Common No. 1	TP16		o	
Spare	TP17			
Audio Switch Output Hi	TP18		o	See Note 2
Audio Switch Output Lo	TP19		o	See Note 2
Spare	TP20			
Audio Switch Loc Input Hi	TP21		o	See Note 2
Audio Switch Loc Input Lo	TP22		o	See Note 2
Cruise Monitor Annunciate	TP23		o	See Note 7
Spare	TP24			
Audio Switch VOR Input Hi	TP25		o	VOR Audio See Note 2
Audio Switch VOR Input Lo	TP26		o	VOR Audio See Note 2
Spare	TP27			
Spare	TP28			
Spare	TP29			
Spare	TP30			

REPLACEMENT PAGE

ATTACHMENT 2

ARINC CHARACTERISTIC NO. 578

STANDARD INTERWIRING (PART 2)

	FUNCTION		ILS RX. BOTTOM INSERT	CONTROL PANEL	JUNCTION BOX	
	LOC Hi Level Inst. Deviation		BP1			
	LOC Lo Level Inst. Deviation		BP2			
¢-1	LOC Hi Level Inst. Dev. Common		BP3			
¢-1	GS Hi Level Inst. Dev. Common		BP4			
	DC (Chassis) Ground		BP5	LPm		DC Ground
	LOC AFCS Dev. No. 2		BP6			
	LOC AFCS Dev. Common No. 2		BP7			
¢-1	LOC Lo Level Inst. Dev. Common		BP8			
	GS Hi Level Inst. Deviation		BP9			
	GS Lo Level Inst. Deviation		BP10			
¢-1	GS Lo Level Inst. Dev. Common		BP11			
	Suggested Spare No. 1		BP12	RPc		
	Suggested Spare No. 2		BP13	RPL		
	GS AFCS Dev. No. 2		BP14			
	GS AFCS Dev. Common No. 2		BP15			
¢-1	LOC AFCS Warning Common		BP16			
¢-1	LOC Hi Level Inst. Warning Common		BP17			
¢-1	LOC Lo Level Inst. Warning Common		BP18			
	Spare		BP19			
	Suggested Spare No. 3		BP20			
	LOC AFCS Warning		BP21			
	LOC Hi Level Instrument Warning		BP22			
	LOC Lo Level Instrument Warning		BP23			
	GS AFCS Warning		BP24			
	GS Hi Level Instrument Warning		BP25			
	GS Lo Level Instrument Warning		BP26			
¢-1	GS AFCS Warning Common		BP27			
¢-1	GS Hi Level Inst. Warning Common		BP28			
	Frequency Select Common		BP29	LPZ		For the parallel connection of an ARINC 568 DME and/or a remote frequency read-out device
	10 MHz Freq. Select	A	BP30	LPA		
		E	BP31	LPE		
	1 MHz Freq. Select	A	BP32	LPF		
		B	BP33	LPG		
		D	BP34	LPJ		
		E	BP35	LPK		
	0.1 MHz Freq. Select	A	BP36	LPL		
		B	BP37	LPM		
		C	BP38	LPN		
		D	BP39	LPP		
		E	BP40	LPR		
	0.05 MHz Freq. Select	C	BP41	LPU		
¢-1	GS Lo Level Inst. Warning Common		BP42			
¢-1	Suggested Spare No. 4		BP43			
¢-1	Suggested Spare No. 5		BP44	RPg		
	Controlled Audio			LPd		To Audio Distribution System - See Note 2
	LOC Audio	Hi	BP45	LPe		
		Lo	BP46	LPc		
	ILS Channel Signal		BP47	LPh		Note 3
	ILS Functional Test (Up/Left)		BP48	RPV		Note 4
	ILS Functional Test (Down/Right)		BP49	RPd		
	NAV Disable		BP50	LPa		Note 6
	115 Volts AC Hot		BP51			1 Amp C/B
	115 Volts AC Cold		BP52			AC Ground
¢-1	Suggested Spare No. 6		BP53			
	Inst. Warning Switch LOC I/P (Hot)		BP54			
	Inst. Warn. Sw. VOR/R-NAV I/P (Hot)		BP55			
	Switched Warning O/P (Hot)		BP56			
	In Test Annunciate		BP57			
	Switched Inst. Warning O/P (Cold)		BP58			
	Inst. Warn. Sw. VOR/R-NAV I/P (Cold)		BP59			
	Inst. Warn. Sw. LOC I/P (Cold)		BP60			
	Deviation Switch ILS I/P (Hot)		BP61			
	Deviation Switch VOR/R-NAV I/P (Hot)		BP62			
	Deviation Switch O/P (Hot)		BP63			
	Deviation Switch ILS I/P (Cold)		BP64			
	Deviation Switch VOR/R-NAV I/P (Cold)		BP65			
	Switched Deviation O/P (Cold)		BP66			
	Deviation/Flag Switch energise		BP67			
	Control Panel Lights	H		LPn		To Control Panel Lighting Supplies See Note 5
		C		LPr		
	On/Off (Ground for On)			RPY		

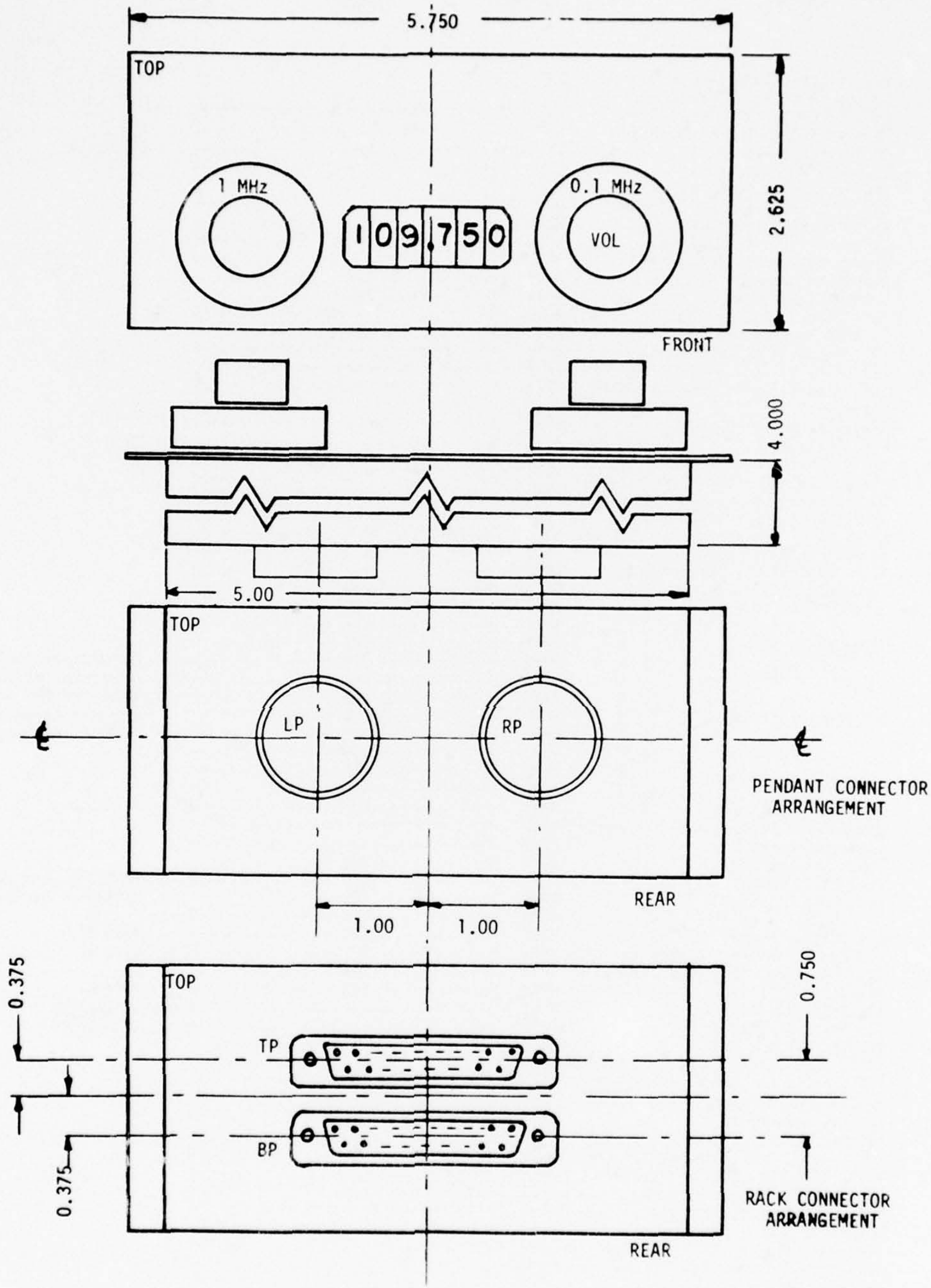
¢-1 denotes an amendment introduced by Supplement No. 1

ATTACHMENT 3

ARINC CHARACTERISTIC NO. 578

STANDARD CONTROL PANEL

OUTLINE DRAWING

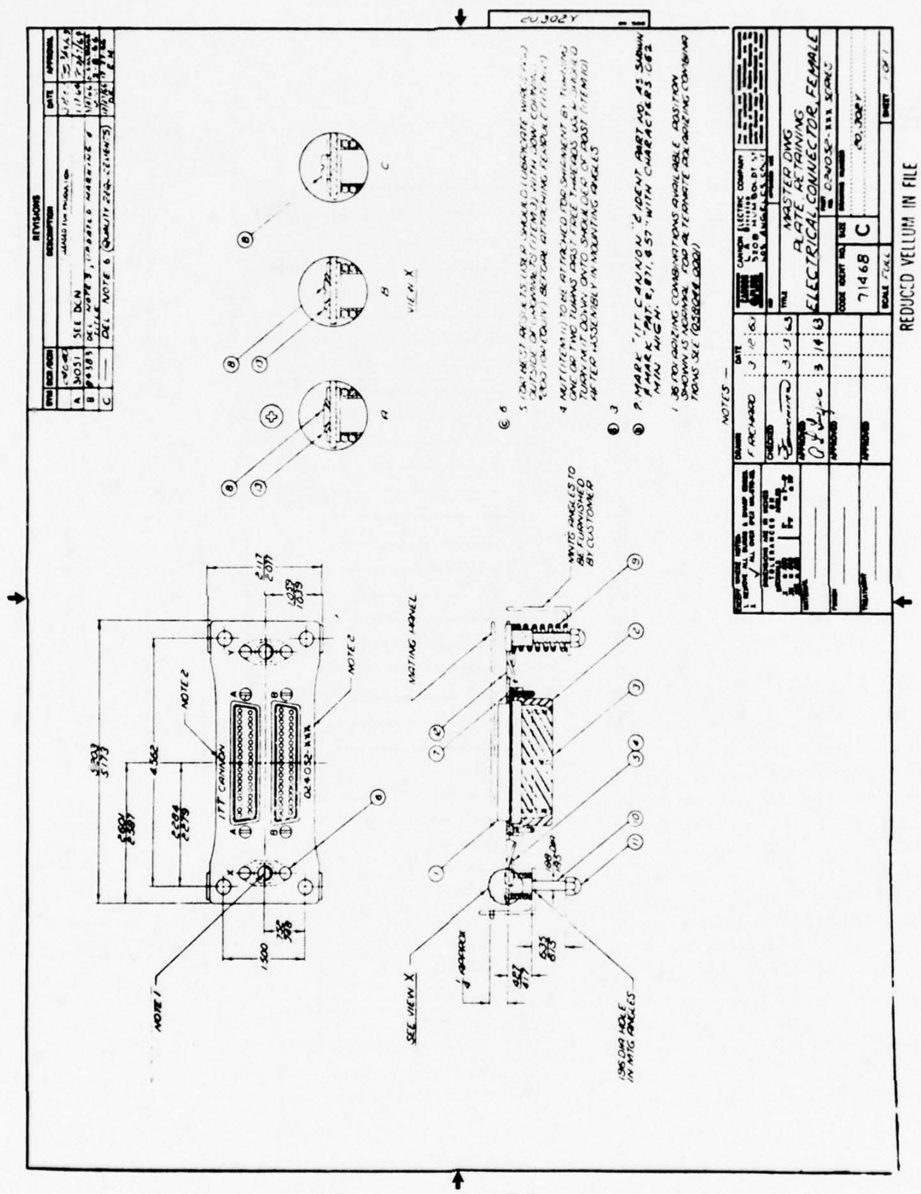


NOTE: Front panel will mount additional switches for DME and Functional Test control, as required.

ATTACHMENT 3 (Cont'd)

ARINC CHARACTERISTIC NO. 578

CONTROL PANEL MOUNTING PLATE ASSEMBLY



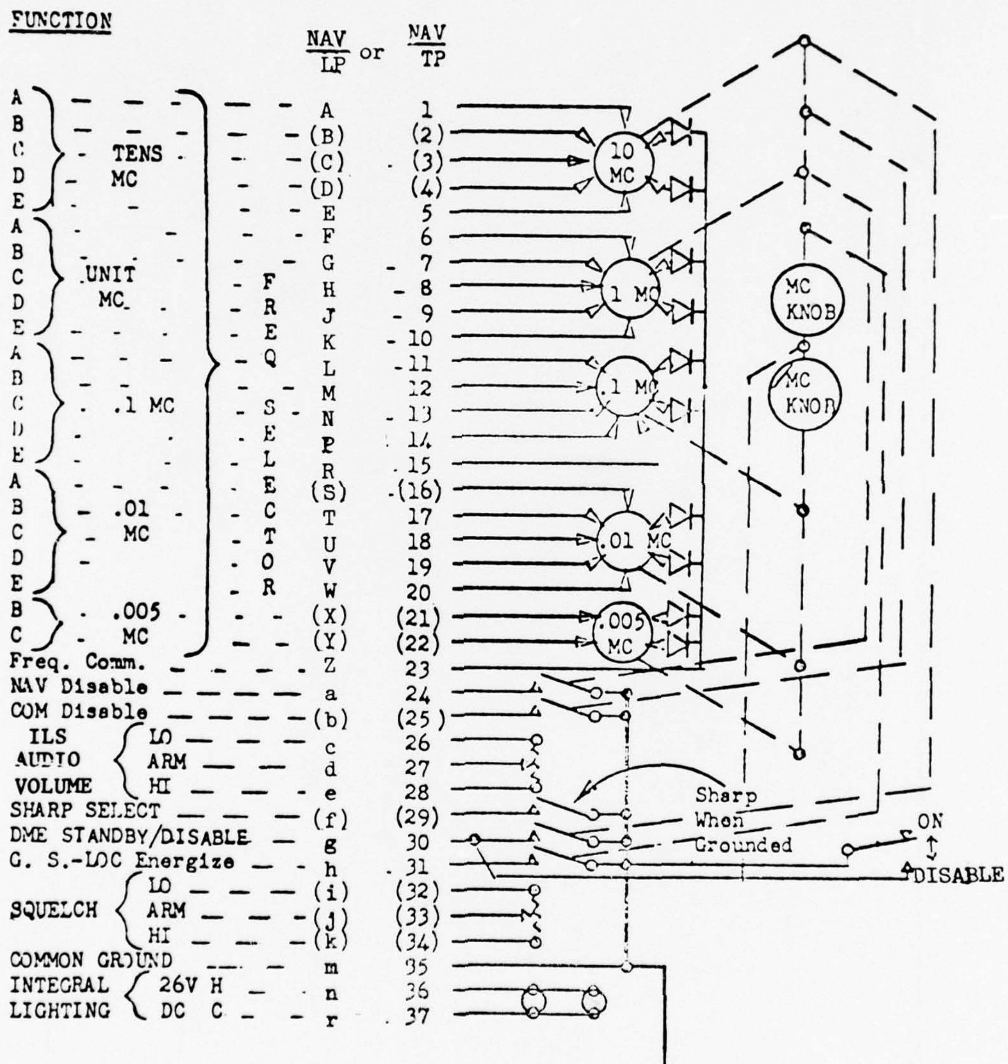
ATTACHMENT 3 (Cont'd)

ARINC CHARACTERISTIC NO. 578

STANDARD VHF NAV/DME CONTROL

PANEL WIRING

Sheet 1 of 2



NOTE: Bracketed letters (or numerals) indicate that the pin is not employed in VHF NAV/DME Control but is assigned for VHF COM Control.

See Second Sheet

ATTACHMENT 3 (Cont'd)

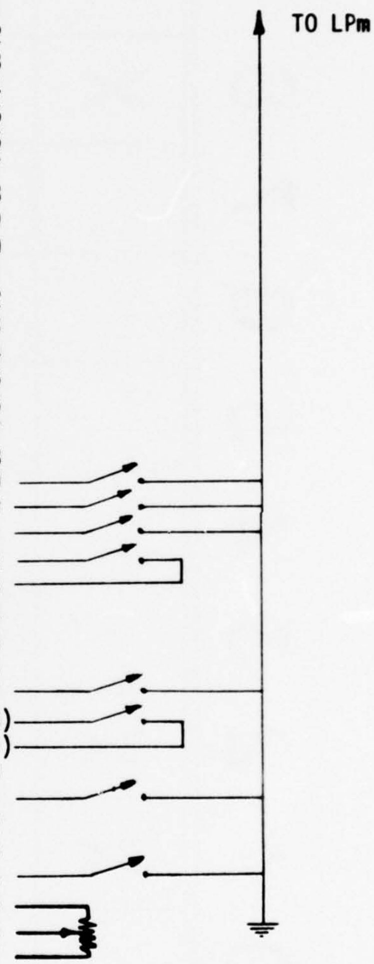
ARINC CHARACTERISTIC NO. 578

STANDARD VHF NAV/DME CONTROL

PANEL WIRING

Sheet 2 of 2

FUNCTION	NAV RP	or	NAV BP
VOR Suggested Spare No. 1	A		1
VOR Suggested Spare No. 2	B		2
VOR Suggested Spare No. 3	C		3
Spares	D		4
	E		5
	F		6
	G		7
	H		8
	J		9
	K		10
ILS Suggested Spare No. 2	L		11
Spares	M		12
	N		13
	P		14
	R		15
	S		16
	T		17
	U		18
ILS Functional Test (Up/Left)	V		19
DME Search Override	W		20
DME On/Off	X		21
ILS/VOR/COM On/Off	Y		22
ILS/VOR/COM On/Off	Z		23
Spare	a		24
Spare	b		25
ILS Suggested Spare No. 1	c		26
ILS Functional Test (Down/Right)	d		27
Squelch Disable Hot	(e)		(28)
Squelch Disable Cold	(f)		(29)
ILS Suggested Spare No. 6	g		30
DME Functional Test	h		31
DME Suggested Spare No. 1	i		32
DME Suggested Spare No. 2	j		33
VOR Functional Test	k		34
VOR Audio Volume LO	m		35
VOR Audio Volume ARM	n		36
VOR Audio Volume HI	r		37



NOTE: Bracketed letters (or numerals) indicate that the pin is not used in VHF NAV/DME Control but is assigned for VHF COM Control.

ATTACHMENT 4

ARINC CHARACTERISTIC NO. 578

FREQUENCY SELECTOR TWO-OUT-OF-FIVE BINARY CODE

	0	1	2	3	4	5	6	7	8	9
A		X	X						X	X
B	X	X		X	X					
C			X	X		X	X			
D					X	X		X	X	
E	X						X	X		X

APPENDIX B-2

FEDERAL AVIATION AGENCY CERTIFICATION REQUIREMENTS FOR ILS AIRBORNE RECEIVING EQUIPMENT

Technical Standard Order C-34C (Airborne ILS Glide Slope Receiving Equipment)

- Requires Compliance with: RTCA Document No. DO-132, *Minimum Performance Standards - Airborne ILS Glide Slope Receiving Equipment*, 15 March 1966, and RTCA Document No. DO-138, *Environmental Conditions and Test Procedures for Airborne Electronics/ Electrical Equipment and Instruments*, 27 June 1968

- Designates: Manner of marking equipment to identify environmental tolerances, manufacturer, and TSO number

  Requires that Manufacturer Furnish to FAA:

  - One copy of Operating Instructions and Equipment Limitations

  - One copy of Installation Procedures, Schematics, and Specifications, and a Listing of Components

  - One copy of *Manufacturer's Test Report*

Technical Standard Order C-35C (Airborne ILS Localizer Receiving Equipment)

- Requires Compliance with: RTCA Document No. DO-131, *Minimum Performance Standards - Airborne ILS Localizer Receiving Equipment*, 15 December 1965, and RTCA Document No. DO-138, *Environmental Conditions and Test Procedures for Electronics/ Electrical Equipment and Instruments*, 27 June 1968

- Designates: Manner of marking equipment to identify environmental tolerances, manufacturer, and TSO number

- Requires that Manufacturer Furnish to FAA:

  - One copy of Operating Instructions and Equipment Limitations

  - One copy of Installation Procedures, Schematics, and Specifications, and a Listing of Components

  - One copy of Manufacturer's Test Report

APPENDIX B-3

RADIO TECHNICAL COMMISSION FOR AERONAUTICS
DOCUMENT DO-131: *MINIMUM PERFORMANCE STANDARDS FOR AIRBORNE ILS LOCALIZER EQUIPMENT*, 15 March 1972

International Coordinating Group I Representatives

Chairman - Federal Aviation Agency
Secretary - Radio Technical Commission for Aeronautics
National Aeronautical Corporation
Aeronautical Radio, Incorporated
Collins Radio Company
Air Transport Association of America
King Radio Corporation
Bendix Radio Division

Minimum Performance Standards under Standard Test Conditions

Centering Accuracy
Deflection AGC Characteristics
Deflection Balance
Visual Course-Deviation Indication
Electrical Course-Deviation Output
Deflection Stability with Modulation Frequency
RF Sensitivity
Voltage Standing Wave Ratio (Receiver)
Emission of Radio Frequency Energy
Selectivity
Warning Signal
Receiver Performance with Two Carriers
Spurious Response
Voice/Identification Audio Output
Voice/Identification Frequency Response
Voice/Identification Audio Distortion
Voice/Identification AGC Characteristic
Antenna Efficiency
Antenna Polarization
Voltage Standing Wave Ratio (Antenna)
Operation of Two Localizer Receivers from the same Antenna

Minimum Performance Standards under Environmental Conditions

Temperature-Altitude Tests

Low-Temperature Test
High-Temperature Test
Decompression Test
Altitude Test

Humidity Test
Shock Test
Vibration Test
Temperature-Variation Test

APPENDIX B-4

RADIO TECHNICAL COMMISSION FOR AERONAUTICS
DOCUMENT DO-132: *MINIMUM PERFORMANCE STANDARDS FOR AIRBORNE ILS GLIDE SLOPE RECEIVING EQUIPMENT,*
15 MARCH 1966

International Coordinating Group I Representatives

Chairman - Federal Aviation Agency
Secretary - Radio Technical Commission for Aeronautics
National Aeronautical Corporation
Aeronautical Radio, Incorporated
Collins Radio Company
Air Transport Association of America
King Radio Corporation
Bendix Radio Division

Minimum Performance Standards under Standard Test Conditions

Centering Accuracy
Deflection AGC Characteristic
Deflection Balance
Visual Course-Deviation Indication
Electrical Course-Deviation Output
Deflection Stability with Modulation Frequency Variation
RF Sensitivity
Voltage Standing Wave Ratio (Receiver)
Emission of Radio Frequency Energy
Selectivity
Warning Signal
Receiver Performance with Two Carriers
Spurious Response
Antenna Efficiency
Antenna Polarization
Voltage Standing Wave Ratio (Antenna)
Operation of Two Glide Slope Receivers from the same Antenna

Minimum Performance Standards under Environmental Conditions

Temperature-Altitude Tests

Low-Temperature Test
High-Temperature Test
Decompression Test

Humidity Test
Shock Test
Vibration Test
Temperature-Variation Test
Voltage/Frequency Variation
Low-Voltage Test
Conducted Voltage Transient Tests
Conducted Audio-Frequency and Susceptibility Test
Audio Frequency Magnetic Field Susceptibility Test
Radio Frequency Susceptibility Test -- Radiated and Conducted
Explosion Test

Appendix A: Test Procedures and Definitions

Appendix B: Statistical Procedure for Use in Tests

APPENDIX B-5

ARINC CHARACTERISTIC 578-3 REFERENCES

Document Number	Title and Description
1. ARINC Specification 410	"Mark 2 Standard Frequency Selection System", 1 October 1961 Describes '2 out of 5' Frequency Selection System to be used in 578 ILS Equipment
2. I.C.A.O. Standard - Annex 10	"International Standards and Recommended Practices, Aeronautical Telecommunications Relevent to ILS", 22 August 1968 Established frequency separation and tolerances when two RF Carriers are used.
3. Radio Technical Commission for Aeronautics Document DO-131	"Minimum Performance Standards for Airborne ILS Localizer Equipment", 15 March 1972 Guidance on effects of two Carrier Localizer Transmissions on Airborne Receiver Performance.
4. I.C.A.O. Standard - Annex 10	"International Standards and Recommended Practices Aeronautical Telecommunications Relevent to ILS", 22 August 1968 Establishes frequency separation tolerances when two RF Carriers are used.
5. RTCA Document No. DO-132	"Minimum Performance Standards - Airborne ILS Glide Slope Receiving Equipment", 15 March 1966 Guidance on effects of two Carrier Localizer Transmissions on Airborne Receiver Performance.

APPENDIX B-5

ARINC CHARACTERISTIC 578-3 REFERENCES (Continued)

Document Number	Title and Description
6. RTCA Document No. DO-131	"Minimum Performance Standards for Airborne ILS Localizer Equipment", 15 March 1972
	Test environment conditions and statistical procedures for determining Proportionality Constant Deviation.
7. RTCA Document No. DO-132	
	Test environment conditions and statistical procedures for determining Proportionality Constant Deviation.
8. RTCA Document No. DO-131	
	Service conditions applicable to Localizer Equipment Stability Requirements.
9. RTCA Docment No. DO-132	
	Service conditions applicable to Glide Slope Equipment Stability Requirements.
10. ARINC Specification 410	"Mark 2 Standard Frequency Selection System", 1 October 1970
11. IBID	
12. IBID	
13. ARINC Specification 404	"Air Transport Equipment Cases and Racking", 31 October 1970
	Standard Equipment Form Factors and Tolerances.

APPENDIX B-5

ARINC CHARACTERISTIC 578-3 REFERENCES (Continued)

	Document Number	Title and Description
14.	ARINC Report No. 414	"General Guidance for Equipment and Installation Designers", 3 September 1968 Guidance on Equipment Racking Dimension Tolerances.
15.	ARINC Report No. 306	"Guidance for Designers of Aircraft Electronic Installations", 1 September 1955 Control Panel Conventions and Dimensions.
16.	ARINC Characteristic 568	"Mark 3 Airborne *Distance* Measuring Equipment", 9 February 1968 Interwiring, Basic Signal Levels, and Power Supply Requirements affecting interface between 568 DME and 578 ILS Equipment.
17.	ARINC Report No. 306	Information on Problems in paralleling Receivers on Single Antenna.
18.	I.C.A.O. Standard - Annex 10	Information Pertaining to International Frequency Allocations.
19.	ARINC Specification 410	Standard Interwiring/Grounding Design
20.	ARINC Report No. 414	Appendix I Lists current publications not specifically mentioned in text of ARINC Characteristic 578 of possible interest to euqipment designers, installers, and users.

APPENDIX C. TACAN AN/ARN-XXX REFERENCES

PART I: EQUIPMENT SPECIFICATION REFERENCES

Specifications

Preservation, Methods of, 18 August 1967 (see Note 2)	MIL-P-116E(3)
Cases, Bases, Mounting, and Mounts, Vibration (For Use with Electronic Equipment in Aircraft), 20 October 1966 (see Note 2)	MIL-C-172C(2)
Crystal Units, Quartz, General Specification for, 31 August 1971 (see Note 2)	MIL-C-3098E(3)
Selection and Installation of Aircraft Wiring, 1972 (see Note 3)	MIL-W-5088
Electronic Equipment, Airborne, General Specification for, 30 November 1971 (see Note 2)	MIL-E-5400N
Control Panel, Aircraft Equipment, Rack or Console Mounted (ASG), 13 September 1960 (see Note 2)	MIL-C-6781B
Panels, Information Integrally Illuminated, 14 April 1967 (see Note 2)	MIL-P-7788D
Meter, Time Totalizing, 31 December 1969 (see Note 2)	MIL-P-7793D
Air Transportability Requirements, General Specification for, 14 August 1969 (see Note 2)	MIL-A-8421C
Finish for Ground Signal Equipment, 11 September 1968 (see Note 2)	MIL-F-14072A
Test Procedures, Reproduction, Acceptance and Life for Aircraft Electronic Equipment, Format for, 1 September 1966 (see Note 2)	MIL-T-18303B
Nomenclature and Identification for Electronic, Aeronautical, and Aeronautical Support Equipment, 29 February 1972 (see Note 3)	MIL-N-18307E
Microcircuits, General Specification for, 16 July 1971 (see Note 2)	MIL-M-38510(1)
Connector, Coaxial Radio-Frequency, General Specification for, 9 April 1970 (see Note 2)	MIL-C-39012B
Solder Bath Soldering of Printed Wiring Assemblies Automatic Machine Type, 2 May 1969 (see Note 2)	MIL-S-46844A
Human Engineering Requirements for Military Systems, Equipment and Facilities, 29 March 1968 (see Note 2)	MIL-H-46855(1)
Connector, Electric, Circular, Environment Resisting, General Specification for, 9 September 1967 (see Note 2)	MIL-C-83723A

Standards

Identification Marking of U.S. Military Property, 5 March 1971 (see Note 3)	MIL-STD-130D
Standards and Specifications, Order of Precedence for the Selection of, 12 November 1969 (see Note 2)	MIL-STD-143D
Test Methods for Electronic and Electrical Component Parts, 14 April 1969 (see Note 2)	MIL-STD-202D Change 1 15 April 1970
Definition of Item Levels, Item Exchangeability, Models, and Related Terms, 7 July 1969 (see Note 2)	MIL-STD-280A
Standard Tactical Air Navigation (TACAN) Signal, 13 December 1967	MIL-STD-291B
Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for, 1 October 1969 (see Note 2)	MIL-STD-415D
Environmental Requirements for Electronic Parts, 2 September 1970 (see Note 2)	MIL-STD-446B
Radio Frequency Spectrum Characteristics, Measurement of, 1 May 1965 (see Note 2)	MIL-STD-449C
Standard General Requirements for Electronic Equipment, 15 October 1970 (see Note 2)	MIL-STD-454C
Electromagnetic Interference Characteristics Requirements for Equipment, 1 August 1968 (see Note 3)	MIL-STD-461A Change 4 9 February 1971

NOTES:
(Recommendations to retain, eliminate, or consider further are based on assumption of no organic maintenance.)

Standards (continued)

Electromagnetic Interference Characteristics, Measurements of, 31 July 1967 (see Note 3)	MIL-STD-462 Change 3 9 February 1971
Maintainability Program Requirements (for Systems and Equipments), 21 March 1966 (see Note 2)	MIL-STD-470
Maintainability Demonstration, 15 February 1966 (see Note 2)	MIL-STD-471 Change 1 9 April 1968
Color Requirements for Individual Color Chips (see Note 2)	FED-STD-595A
Failure Rate Sampling Plans and Procedures, 17 April 1968 (see Note 2)	MIL-STD-690B
Electric Power, Aircraft Characteristics and Utilization of, 9 August 1966 (see Note 2)	MIL-STD-704A Change 2 5 May 1970
Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety, 25 August 1966 (see Note 2)	MIL-STD-721B Change 1 10 March 1970
Reliability Prediction, 15 May 1963 (see Note 2)	MIL-STD-756A
Reliability Tests Exponential Distribution, 15 November 1967 (see Note 2)	MIL-STD-781B Change 1 28 July 1969
Reliability Program for Systems and Equipment Development and Production, 28 March 1969 (see Note 2)	MIL-STD-785A
Environmental Test Methods [With Notice 2 (11)], 15 June 1967 (see Note 3)	MIL-STD-810B
System Safety Program for Systems and Associated Systems and Equipment, Requirements for, 15 July 1969 (see Note 2)	MIL-STD-882
Test Methods and Procedures for Micro Electronics, 1 May 1968 (see Note 2)	MIL-STD-883 Change 2 20 November 1969
Human Engineering Design Criteria for Military Systems, Equipment and Facilities, 15 May 1970 (see Note 3)	MIL-STD-1472A

Regulations

Test and Evaluation of Systems, Subsystems and Equipment, 12 May 1972 (see Note 3)	AFR 80-14
Department of Defense Engineering for Transportability Program, 9 August 1971 (see Note 3)	AFR 80-18 Change 1 6 October 1971

Manuals

Specifications and Standards Manual, 18 October 1971 (see Note 2)	AFLCM 81-1
Optimum Repair-Level Analysis (ORLA), 25 June 1971 (see Note 2)	AFLCM/AFSCM 800-4

Handbooks

Reliability Stress and Failure Rate Data for Electronic Equipment, 1 December 1965 (see Note 2)	MIL-HDBK-217A Change 2
Maintainability Prediction, 24 May 1966 (see Note 2)	MIL-HDBK-472

Other Publications

RADC Reliability Notebook, Volume 2, September 1967 (see Note 2)	AD 821640
Personnel Subsystems, 1 January 1972 (see Note 2)	AFSC DH 1-3
Maintainability, 20 December 1970 (see Note 2)	AFSC DH 1-9 Rev. 1, 2, 3
Air Transport Equipment Cases and Racking, 31 December 1970 (see Note 1)	ARINC 404 Sup. 1-8 Incl.

Other Publications (continued)

Mark-3 Airborne Distance Measuring Equipment, 1 June 1971 (DME may be used in ALS) (see Note 3)	ARINC 568 Sup. 1 Incl.
VOR Receiver, 5 February 1971 (see Note 2)	ARINC 579-1
Mark-2 Air Transport Area Navigation System, 26 August 1971 (see Note 2)	ARINC 582-2
Development of Integrated Logistic Support for Systems and Equipment (I&L), 1 October 1970 (see Note 2)	DoD 4100, 35G
FAA Advisory Circular No. 00-31 (10 June 1970) U.S. National Aviation Standard for the VORTAC System (see Note 2)	
I.C.A.O. Standard - Annex 10 (22 August 1968) Amendments (March 1972), Volume 1: Aeronautical Telecommunications Annex 10 to Convention of International Civil Aviation, Part 1 Equipment and Systems - Part 2 Frequencies; Volume 2: Communication Procedure (see Note 1)	
National Electric Code, Pamphlet No. 70 (see Note 3)	

PART II: ADDITIONAL REFERENCES PER STATEMENT OF WORK

Specifications

Time Compliance Technical Orders (TCTOs), Preparation of, 31 July 1972 (see Note 2)	MIL-T-38804
General Requirements for Preparation of Technical Manual, 1 January 1968 (see Note 3)	MIL-M-38784
Calibration System Requirements, 9 February 1962 (see Note 2)	MIL-C-45662A
Bonding, Electrical, and Lightning Protection for Aerospace Systems, 31 August 1970 (see Note 2)	MIL-B-5087B(2)
Technical Reviews and Audits for Communication/Electronic/Meteorological Systems and Related Equipment, 1 May 1971 (see Note 2)	MIL-R-83313
Packaging, Materials Handling, and Transportability, System and System Segments, General Specifications for, 6 June 1972 (see Note 3)	MIL-P-9024G
Quality Program Requirements, 16 December 1963 (see Note 2)	MIL-Q-9858A

Standards

Marking for Shipment and Storage, 28 April 1970 (see Note 3)	MIL-STD-129E
Definition and System of Units, Electromagnetic Interference Technology, 9 June 1966 (see Note 3)	MIL-STD-463
Radar Engineering Design Requirements, Electromagnetic Compatibility, 1 December 1966 (see Note 2)	MIL-STD-469 Change 1 30 March 1967
Configuration Control - Engineering Changes, Deviations and Waivers, 30 October 1968 (see Note 2)	MIL-STD-480
Configuration Control - Engineering Changes, Deviations and Waivers (Short Form), 18 October 1972 (see Note 2)	MIL-STD-481A
Configuration Management Practices for System Equipment, Munitions, and Computer Programs, 31 December 1970 (see Note 2)	MIL-STD-483 Change 1 1 June 1971
Specification Practices, 30 October 1968 (see Note 2)	MIL-STD-490 Change 2 18 May 1972

Regulations

Policies and Procedures Governing AF Printing and Duplicating, 12 April 1965 (see Note 2)	AFR 6-1
Air Force Technical Orders System, 20 March 1968 (see Note 2)	AFR 8-2
Configuration Management, 1 February 1962 (see Note 2)	AFR 65-3

Regulations (continued)

Engineering Inspections, 23 May 1963 (see Note 2)	AFR 80-28
Official Mail - Policies and Procedures, 15 October 1968 (see Note 2)	AFR 182-15
Acquisition and Management of Contractor Data, 16 May 1966 (see Note 2)	AFR 310-1
Marking of Shipments, 31 March 1969 (see Note 2)	ASPR 7-104.68
Special ESD Identification Label Clause, 1 May 1970 (see Note 3)	ESD ASPR Supplement 7-104.68
Instruction for Completing DD Form 1423, 29 August 1969 (see Note 2)	ASPR F200.1423

Manuals

Maintenance Management (see Note 2)	AFM 66-1
Transportation of Material, 30 November 1970 (see Note 2)	AFM 75-1
Military Traffic Management Regulation, 15 November 1969 (see Note 2)	AFM 75-2
Packaging and Handling of Dangerous Materials for Transportation by Military Aircraft, 9 August 1971 (see Note 2)	AFM 71-4
Automatic Data Processing, Planning, Programming and Budgeting Information, 20 March 1972 (see Note 2)	AFM 300-3
Technical Publications Acquisition Management, 14 March 1971 (see Note 2)	AFSCM 310-2
Configuration Management for Systems, Equipment, Munitions, and Computer Programs (see Note 2)	AFSCM/AFLCM 375-7
Optimum Repair Level Analysis (ORLA) (may consider for ultimate support concept) (see Note 2)	AFSCM 800-4

Handbooks

General Design Factors, 1972 (see Note 2)	AFSC DH 1-2
AFSC Design Handbook - Electromagnetic Compatibility, 10 January 1972 (see Note 2)	AFSC DH 1-4
Ground Equipment and Facilities, 1 February 1969 (see Note 2)	AFSC DH 2-6
Air Force Technical Information File of Aerospace Ground Equipment, 1 January 1971 (see Note 2)	MIL-HDBK-300

Other Publications

Aerospace Ground Equipment Identification/Selection Acquisition/Provisioning Document for USAF Contracts, 4 April 1966 (see Note 3)	AFAD 71-685
Spare/Repair Parts Provisioning Document for USAF Aerospace and Associated Equipment Contracts, July 1969 (see Note 2)	AFAD 71-688
Integrated Logistic Support Implementation Guide for DoD Systems and Equipments, March 1972 (see Note 2)	DoD 4100.35G
Department of Defense Authorized Data List, April 1972 (see Note 2)	DoD ADL (TD-3)
AF Technical Order System, 1972 (see Note 2)	T.O. 00-5-1

NOTES:

(Recommendations to retain, eliminate, or consider further are based on assumption of no organic maintenance.)

1 = Retain
2 = Eliminate
3 = Consider cost impact and justify value in previous applications as well as relevance to this application or reference for information or guidance only.

APPENDIX D

TECHNICAL DESCRIPTION OF REPRESENTATIVE USAF ILS EQUIPMENT

Table D-1 presents design and other technical data on contemporary Air Force ILS equipment.

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Table D-1. TECHNICAL DESCRIPTION OF REPRESENTATIVE USAF ILS EQUIPMENT

Features and Physical Characteristics	VOR/Localizer Navigation Receivers					Glide Slope Receiver			
	VOR101	AN/ARN-14	51R6	AN/ARN-31[5]	AN/ARN-58[6]	51V-4	AN/ARN-67	AN/ARN-18	800B
Manufacturer	Collins	Bendix	Collins	Several	Several	Collins	Sparton	Hoffman	Wilcox
Volume (Ft.)[1,2]	1.0	1.3	0.3	0.63	0.5	0.13	0.2	0.5	0.1
LRUs[3]	2	4	2	4	3	2	1	1	1
Weight (lbs.)	27.5	41	15	24	17.7	7.25	7.5	13	4.5
Number of Channels	200	200	200	200 20	200 20 1	20	20	20	20
Date Equipment Source Coded	1959	1954	1963	1959	1961	1963	1962	1955	1965
Technology									
• Tube	X	X		X			X	X	
• Solid State	X		X		X	X			X
Power Requirements	27.5 Vac 400 Hz 27.5 Vdc	27.5 Vac 400 Hz 26 Vdc	26 Vac 400 Hz 27.5 Vdc	115 Vac 400 Hz 26.5 Vdc	26 Vac 400 Hz 27.5 Vdc	26 Vac 400 Hz 27.5 Vdc	115 Vac 400 Hz 27.5 Vdc	115 Vac 400 Hz 26.5 Vac	26 Vac 400 Hz 27.5 Vac
Accuracy	1°	1°	1°	1°	1°	±10 μA	±10 μA	±10 μA	±10 μA
Senstivity[4]	3 μV	3 μV	3 μV	3 μV	3 μV	3 μV	3 μV	3 μV	3 μV
Operating Temperature Range (°C)	-55 to +55	-54 to +55	-54 to +55	-54 to +98	-54 to +71	-54 to +55	-54 to +71	-54 to +71	-54 to +55
Altitude (1000 ft.)	45	50	45	70	70	45	70	70	45

1 Airline Case Equivalents:
1/4 ATR Short = 0.12 ft^3: 3/8 ATR Short = 0.2 ft^3: 1/2 ATR Short = 0.3 ft^3: 1/2 ATR Standard = 0.9 ft^3.

2 The volumes shown cannot be compared in each case as different equipments include more than one function in some cases.

3 Does not include mounts where required.

4 A signal plus noise-to-noise ratio of 6 dB modulated 30 percent at 1000 cycles.

5 Includes glide slope.

6 Includes glide slope/marker beacon.

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APPENDIX E

TECHNICAL DESCRIPTION OF
REPRESENTATIVE AIRLINE ILS EQUIPMENT

Table E-1 presents design and other technical data on contemporary airline ILS equipment.

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Table E-1. TECHNICAL DESCRIPTION OF REP

Features and Physical Characteristics	VOR/Localizer Navigation Receivers					TSO C36 Requirement
	RVA-33A [1]	RN-26C [2]	51RV-1 [3]	51RV-2B [4]	806A [5]	
Manufacturer	Bendix	Bendix	Collins	Collins	Wilcox	
Size	3/8 ATR Short	1/2 ATR Short	1/2 ATR Short	1/2 ATR Short	1/2 ATR Standard	-
Number of LRUs	1	1	1	1	1	-
Weight (lbs.)	10	23	18.5	18.2	9	-
Certification	TSO'd	TSO'd	TSO'd	TSO'd	TSO'd	-
Number of Channels	200	200/40GS	200/40GS	200/40GS	200	-
Operational Date					1966	
Technology						
• Discrete	X	X	X	X	X	
• IC's	X	X	X	X		
• Tubes						
Power Requirements	115 Vac 0.9 A 400 Hz	28 Vdc	28 Vdc 26 Vac 400 Hz 40 W Max	27.5 Vdc 26 Vac 400 Hz		-
Accuracy	0.4°	0.2°	0.5°	0.5°	0.5°	FAA Handbo 8200.1 1.0°
Sensitivity (dBm)	-93	-101	-97	-97	-107	-77
Operating Temperature Range (°C)	-54 to +71 (DO-138) Cat. G	-55 to +55				DO-138
Altitude (1000 ft.)	20* (DO-138) Cat. G	Same as RVA-33A	Same as RVA-33A	Same as RVA-33A	Same as RVA-33A	DO-138

*Assumes location in pressurized part of the aircraft.

1. Complies with TSO C34b, ARINC 547, and ARINC 579; R-Nav outputs available.
2. Complies with TSOs C34, C36, C40, ARINC 547, and ARINC 579; built-in GSR; R-Nav outputs available.
3. Complies with TSOs C34a, C36a, C40a, ARINC 547, and ARINC 579; built in GSR; R-Nav capability.
4. Complies with TSOs C34b, C36b, C40a, ARINC 547, and ARINC 579; built-in GSR; R-Nav capability, dual-channel VOR and ILS moni
5. Complies with TSO C-36, ARINC 579.

AL DESCRIPTION OF REPRESENTATIVE AIRLINE ILS EQUIPMENT

SA[5]	TSO C36 Requirements	ARINC Characteristic 579-1 Recommendations	Glide Slope Receivers: GSA-8A [1]	Glide Slope Receivers: 51V-5 [1]	Glide Slope Receivers: Series 800 [2]	TSO C36 Requirements	ARINC 551/579 Recommendations
			Bendix	Collins	Wilcox	-	
Standard	-	3/8 ATR Short	1/4 ATR Short	1/4 ATR Short	1/4 ATR Short		1/4 ATR Short
	-	1	2	1	1	-	1
	-	7-12	7.8	3.5	4.5	-	4-6
	-	Recommends TSO Compliance	TSO'd	TSO'd	TSO'd	-	Recommends TSO Compliance
	-	160	20	20	20	-	20
			1959	1965	1962	-	
			X	X	X		
			X				
	-	115 Vac 400 Hz (MIL-STD-704)	27.5 Vdc, 0.29A; 115 Vac, 400 Hz 0.34A			-	27.5 Vdc 115 Vac 400 Hz
	FAA Handbook 8200.1 1.0°	1.0° Installed 0.25° Bench	-	2.5 μA	1.0 μA	FAA Handbook 8200.1 10 μA	IAW ICAO Annex 10 9μA
	-77	-90	-81	-81	-87	-81	-90
	DO-138	IAW TSO	-54 to +71 (DO-138) Cat. G	Same as GSA-8A	Same as GSA-8A	DO-138	IAW TSO
	DO-138	15*	20* (DO-138) Cat. G	Same as GSA-8A	Same as GSA-8A	DO-138	15*

annel VOR and ILS monitoring.

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APPENDIX F

ALS/AIRCRAFT INSTALLATION DATA

AIRCRAFT TYPE: C-141A

LOCATION OF MAIN AVIONICS EQUIPMENT: Forward avionics bay just aft of radome bulkhead below cockpit.

AVAILABLE SPACE: Can accommodate small units in forward bay.

EQUIPMENT DIMENSIONS: Generally conform to standard ATR sizes.

EQUIPMENT MOUNTING AND RACKING: Most equipments have individual mounts in standard airline racks.

EQUIPMENT COOLING: In rack, per ARINC 404, where required.

AVIONICS BAY ENVIRONMENT:

TEMPERATURE: Average $75^{\circ}F$ with ambient extremes for aircraft start.

ALTITUDE: Pressurized environment.

VIBRATION: Random vibration levels in the forward fuselage area up to 5g RMS. Levels should be similar to commercial airline aircraft.

SHOCK: Not critical.

OTHER: Pressurized to cabin level.

AIRCRAFT POWER: 115 VAC 400 Hz 3Ø; 28 VAC derived by T-R units.

WEIGHT - CG RESTRICTIONS: No special restrictions

TYPE CONNECTORS: Generally DPX on the unit back located IAW ARINC 404.

DISPLAYS: Existing ADI; new plan position or chart display may be needed for curved or angled approach.

CONTROLS: Probable custom panel for joint ILS/ALS use. No spare panel space available in cockpit.

FAILURE WARNING/ALERT: Existing fault panel; AWLS uses enroute test monitoring and pre-land test (pilot exercised).

INTERFACES

AUTOPILOT: PB-60A autopilot, Analog Inputs, existing CAT III capability for coupled approaches on ILS with flare and auto-throttle.

R-NAV (or other) EXISTING COMPUTERS: Dual CADC, Flare and vertical navigation computers - all special purpose.

R. ALTIMETER: Existing MDA indication.

PROBABLE ALS ANTENNA LOCATIONS: Nose area below radar antenna, and aft belly.

CABLE RUN LENGTHS

FWD ANTENNA TO ANGLE RX OR DME: 10'

FWD ANTENNA TO RF HEAD: < 2'

REAR ANTENNA TO ANGLE RX OR DME: 80'

REAR ANTENNA TO RF HEAD: < 2'

POTENTIAL EMI/EMC PROBLEMS: High-power radar close to forward antennas.

REMARKS: Can use airline equipment unless special tactical version of the ALS is required.

ALS/AIRCRAFT INSTALLATION DATA

AIRCRAFT TYPE: A-37B

LOCATION OF MAIN AVIONICS EQUIPMENT: Avionics bay in after fuselage.

AVAILABLE SPACE: Very limited.

EQUIPMENT MOUNTING AND RACKING: All equipments use vibration isolation mounts.

EQUIPMENT COOLING: Ambient convection. Avionics bay cooled by RAM air flow.

AVIONICS BAY ENVIRONMENT:

TEMPERATURE: $-65^{\circ}F$ to $+172^{\circ}F$

ALTITUDE: 0 - 25,000'

VIBRATION: Not determined.

SHOCK: Not determined.

OTHER: Aircraft is not pressurized; avionics bay exhaust fan for ground use-seldom used.

AIRCRAFT POWER: 28 VDC main power from aircraft generators and batteries
115 VAC 400 Hz 3Ø available from inverter.

WEIGHT - CG RESTRICTIONS: Forward CG problems will probably dictate installation in the AFT avionics bay.

TYPE CONNECTORS: Various connectors, both MS and rack and panel.

DISPLAYS: Existing ID-387.

CONTROLS: Probably combine with ILS on center lower instrument panel.

FAILURE WARNING/ALERT: Standard flags in ID-387 unit.

INTERFACES

AUTOPILOT: N/A

R-NAV (or other) EXISTING COMPUTERS: N/A

R. ALTIMETER: N/A

PROBABLE ALS ANTENNA LOCATIONS: Aircraft nose (ILS antenna is in the vertical stabilizer).

CABLE RUN LENGTHS

FWD ANTENNA TO ANGLE RX OR DME: 15'

FWD ANTENNA TO RF HEAD: 1 to 2'

REAR ANTENNA TO ANGLE RX OR DME: Not Used

REAR ANTENNA TO RF HEAD: Not Used

POTENTIAL EMI/EMC PROBLEMS: No apparent problems.

REMARKS:

ALS/AIRCRAFT INSTALLATION DATA

AIRCRAFT TYPE: F-15

LOCATION OF MAIN AVIONICS EQUIPMENT: Central and forward bays. (Aft cockpit area noted in the AFIT study was stated as not available)

AVAILABLE SPACE: Unknown

EQUIPMENT MOUNTING AND RACKING: Most equipment is hard-mounted (some exceptions)

EQUIPMENT COOLING: Forced air input through back of equipment racks and exhausted into the compartment.

AVIONICS BAY ENVIRONMENT:

TEMPERATURE: Not determined.

ALTITUDE: Pressurized level not specified.

VIBRATION: Stated as quite severe 9.5g RMS 50 to 2000 Hz (up to 16g RMS adjacent to RT side Gun)

SHOCK: 15g

OTHER: Central and forward avionics bays are pressurized.

AIRCRAFT POWER: 115 VAC 400 Hz 3Ø per MIL-STD-704A

WEIGHT - CG RESTRICTIONS: Not determined.

TYPE CONNECTORS: MS connectors on Box face (for most units)

DISPLAYS: Existing FDI, ADI, HUD probably adequate.

CONTROLS: Probable custom panel for CNI.

FAILURE WARNING/ALERT: Standard flags, no annunciator - existing ILS is not connected to the BITE indicator panel.

INTERFACES

AUTOPILOT: Not equipped for coupled approach.

R-NAV (or other) EXISTING COMPUTERS: Central computer provides FDI input - indirectly controls HUD and ADI.

R. ALTIMETER: Not applicable.

PROBABLE ALS ANTENNA LOCATIONS: Forward area under nose.

CABLE RUN LENGTHS

FWD ANTENNA TO ANGLE RX OR DME: 35'

FWD ANTENNA TO RF HEAD: 5' to 10'

REAR ANTENNA TO ANGLE RX OR DME:
REAR ANTENNA TO RF HEAD:
Not determined.

POTENTIAL EMI/EMC PROBLEMS: Not determined.

REMARKS: Could not verify dimensions or environment. Stated vibration levels appear excessive. Temperature and altitude variations not determined. For these reasons, the A-7D was selected to replace the F-15 as the "Standard" ALS vehicle.

ALS/AIRCRAFT INSTALLATION DATA

AIRCRAFT TYPE: A-7D

LOCATION OF MAIN AVIONICS EQUIPMENT: Avionics bays on both sides of the aircraft accessible from outside the aircraft.

AVAILABLE SPACE: None

EQUIPMENT MOUNTING AND RACKING: All equipments use vibration isolation mounts (individual or rack). Custom racking for variable equipment dimensions.

EQUIPMENT COOLING: Generally convection cooled (a few units have special forced-air ducts). Avionics bays intake cooling RAM air and have an exhaust fan for ground operation.

AVIONICS BAY ENVIRONMENT:

TEMPERATURE:	-65° to +180°F (+130°F for forced air cooled units).
ALTITUDE:	0 to 45000'
VIBRATION:	Not determined. Existing avionics spec'ed to curve I, MIL-E-5400 (10g)
SHOCK:	Not determined.
OTHER:	Avionics bays are unpressurized.

AIRCRAFT POWER: 115 VAC 400 Hz 3Ø primary, 28 VDC (derived from T-R units).

WEIGHT - CG RESTRICTIONS: No special restrictions.

TYPE CONNECTORS: Majority of units use DPX or other rack and panel connectors.

DISPLAYS: Existing heads-up display, chart display, ADI probably adequate for ALS

CONTROLS: Probable custom panel for joint ILS/ALS use. Some spare space available.

FAILURE WARNING/ALERT: Aircraft annunciator panel does not now accommodate ILS Standard ADI flags.

INTERFACES

AUTOPILOT: Can accept analog inputs but does not now have coupled approach capability. Does not interface with central computer.

R-NAV (or other) EXISTING COMPUTERS: Flight director computer (analog) has input to HUD signal processor and ADI.

R. ALTIMETER: MDA indication to pilot.

PROBABLE ALS ANTENNA LOCATIONS: Forward antennas in nose scoop radome; aft antenna on aircraft belly forward of tail hook.

CABLE RUN LENGTHS

FWD ANTENNA TO ANGLE RX OR DME: 26'

FWD ANTENNA TO RF HEAD: <1'

REAR ANTENNA TO ANGLE RX OR DME: 8'

REAR ANTENNA TO RF HEAD: < 1'

POTENTIAL EMI/EMC PROBLEMS: J-band radar in nose; G-band radar altimeter antenna on belly; APR-36 antenna in nose scoop.

REMARKS: Avionics bays are currently jammed. Addition of <u>any</u> equipment will be difficult without first removing something.

APPENDIX G

INSTALLATION/INTEGRATION "REQUIREMENTS" OF AN ARINC CHARACTERISTIC

A. ARINC Characteristic 578-2, "Airborne ILS Receiver"

Parameter/Element	Requirement
Receiver-Unit Form Factor	Specific: Short 3/8 ATR case
Main Connector	Specific: DPX2MA-32C2P67P-34B-0053 (or equivalent)
ATE Connector	Specific: DPA-32-34S-002 (or equivalent)
Connector Locations	Specific: Unit rear, per outline control drawing
Dimension Tolerances	Reference: ARINC Specification 404
Hold-Downs	Reference: ARINC Specification 404
Projections	Reference: ARINC Specification 404
Handles	Reference: ARINC Specification 404
Extractors	Reference: ARINC Specification 404
Weight Limits	Reference: ARINC Specification 404
CG Limits	Reference: ARINC Specification 404
Racking Tolerances	Reference: ARINC Report 414
Thermal Design	Specific: Forced-air cooling not required
Cooling Provisions	Reference: Case drilled per ARINC Specification 404
Indicators	Not constrained
Indicator Interface	Specific: Rigidly defined
Antenna Form Factor	Not constrained
Antenna Function	Specific: Pattern coverage and polarization
Antenna Interface	Specific: Match 50-ohm cable with VSWR $\leq$ 5:1
Receiver-Unit Weight	Guidance: Expected range - 8 to 12 lbs
Control Panel Weight	Guidance: Expected range - 1 to 2 lbs
Interwiring Interface	Specific: Pin connectors per attached drawing

A. ARINC Characteristic 578-2, "Airborne ILS Receiver" (continued)

Parameter/Element	Requirement
Primary Power Input	Reference: 115 Vac, 380 to 420 Hz 1Ø, per MIL-STD-704 (Cat. B)
Circuit Protection	Specific: Single 1-amp circuit breaker
Power Control Circuitry	Specific: On/off switching not to be included in the unit
Common Ground	Guidance: May be chassis-grounded; not for AC returns
Common Cold	Guidance: Not for grounding purposes
Standard Outputs	Specific: Rigidly defined
Interference Rejection	Guidance: Provide rejection circuitry as practicable
Paralleled (Redundant) Outputs	Specific: AFCS outputs to be paralleled for integrity testing/monitoring
Instrumentation Outputs	Specific: High and low levels for both azimuth and glide slope to permit display design options
Warning Signal Outputs	Specific: Two high-level and one low-level for both azimuth and glide slope; binary operation
Control Panel Form Factor	Reference: ARINC Report 306
Control Panel Receptacles	Specific: Bendix PYGMY PT02A-39PY and PTO2A-20-39PZ (Alternate: Cannon D series)
Receptacle Locations	Specific: Left and right rear on horizontal center line
Controls	Reference and Guidance: ARINC Characteristic 568 and customer option
Integral Lighting	Specific: Any combination of 26V or 5V ac or dc, with customer choice of red or white color
ATE Provisions	Specific: Code resistor-pin assignments; necessary functions not defined

B. ARINC Specification 404, "Air Transport Equipment Cases and Racking"

Parameter/Element	Requirement
Equipment Case Sizes	Specific: Variety of sizes in two lengths, several widths, one maximum height, referenced to one ATR

B. ARINC Specification 404, "Air Transport Equipment Cases and Racking" (continued)

Parameter/Element	Requirement
Dimension Tolerances	Specific: Tolerances indicated in a series of drawings
Connector Types	Specific: DPA, DPD, DPX (or equivalent) single or twin
Connector Locations	Specific: Indicated in a series of drawings
Index Pins	Specific: Indexing method (codes registered in ARINC Report 406A)
Hold-Downs	Specific: Pins, latches, thumbscrews; but permits some selection
Projections	Guidance: Discourages use, especially on unit back; provides dimension and location limits
Handles	Specific: Projecting dimension limit; otherwise not discussed
Extractors	Guidance: Provides dimensional standards
Cooling Provisions	Specific: Details location and dimensions of bottom orifice
CG and Weight Ranges	Guidance: Provides table of ranges appropriate to the various case sizes
Shock/Vibration Mounts	Guidance: Offers design discussion; clearance dimensions
Rack-Loading Limits	Specific: 120 lbs maximum (standard-load shelf)

C. ARINC Specification 408, "Air Transport Indicator Cases and Mounting"

Parameter/Element	Requirement
Indicator Shape and Dimensions	Specific: Variety of dimensions in several heights and widths (square case), one maximum length, referenced to an ATI
Mounting Method	Specific: Front, rear, or clamp mounting available
Lighting	Guidance: 5V, internal, red color preferred
Connector	Guidance: Bendix PYGMY (MIL-C-26482)
Connector Locations	Guidance: Preferred locations indicated on drawings

C. ARINC Specification 408, "Air Transport Indicator Cases and Mounting" (continued)

Parameter/Element	Requirement
Cooling	Guidance: Design discussions only
Visibility	Guidance: Shape optional; minimum viewing angle of 30°
Knobs	Guidance: Location, direction of rotation

D. ARINC Report 406A, "Airborne Electronic Equipment Standardized Interconnections and Index Pin Codes"

This document lists pin connections for specific equipments by manufacturer, along with registered index pin codes.

E. ARINC Report 714, "Air Transport Automatic Flight Control System"

NOTE: All items in this report are guidance only; standardization is stated as impractical.

Parameter/Element	Requirement
Azimuth Path Guidance	Input from ILS (ALS)
Elevation Path Guidance	Input from ILS (ALS)
Auto Throttle Interface	Reference: ARINC Characteristic 558
Primary Power Input	Reference: 115 Vac 400 Hz per MIL-STD-704 and ARINC Specification 413
Flight Director System	AFCS coupler to provide signals for FDI
Monitoring and Failure Detection	"Fail-Operational" may require redundancy; warning signal provided when any channel is disconnected
Landing Sequence Annunciator	Possible Indications: Glide-slope arm Glide-slope capture Flare Runway-align

F. ARINC Specification 413, "Guidance for Aircraft Electrical Power Utilization and Transient Protection"

NOTE: Provides design guidance to supplement and interpret MIL-STD-704. General extension for transient susceptibility limits and testing impedances. Discusses interference control through single point grounding, twisted-pair wires and shielding.

G. ARINC Report 415-2, "Operational and Technical Guidelines on Failure Warning and Functional Test"

NOTE: Provides design guidance and recommendations for "minimum requirements" and "customer need" relating to various avionics equipments. No specifics relating to equipment installation are included.

H. ARINC Characteristic 558, "Air Transport Automatic Throttle System"

NOTE: Provides specific requirements and design guidance for ATS. There is no direct interconnection with the ILS (ALS) units. Control signals are derived from the air data computer and/or angle-of-attack sensor to maintain speed or angle-of-attack during approach and landing.

I. ARINC Specification 419, "Digital Data System Compendium"

NOTE: This specification describes a classification code to be used when digital interface requirements must be spelled out in equipment characteristics. No standard system as yet exists, and the classification scheme adapts to variations relating to the message carried, the physical/functional interface design, the digital logic used, and the timing or synchronization elements.

J. ARINC Characteristic 568-3, "Mark-3 Airborne Distance Measuring Equipment"

Parameter/Element	Requirement
Interrogator Unit Form Factor	Specific: Short 1/2 ATR case
Main Connector	Specific: DPX2MA-AC3P-67P-34B-0019 (or equivalent)
ATE Connector	Specific: DPX2MA-106PW8S-34B-0000 (or equivalent)
Connector Locations	Specific: Unit rear, per outline control drawing
Dimension Tolerances	Reference: ARINC Specification 404
Hold-Downs	Reference: ARINC Specification 404
Projections	Reference: ARINC Specification 404
Handles	Reference: ARINC Specification 404
Extractors	Reference: ARINC Specification 404
Weight Limits	Reference: ARINC Specification 404
CG Limits	Reference: ARINC Specification 404
Racking Tolerances	Reference: ARINC Report 414

J. ARINC Characteristic 568-3, "Mark-3 Airborne Distance Measuring Equipment" (continued)

Parameter/Element	Requirement
Cooling Provisions	Reference: ARINC Specification 404; internal blower option
Indicator Type	Guidance: Single, dual, or combined; mechanical or light bar
Indicator Form Factor	Specific: Per outline drawing
Indicator Mount	Specific: Per outline drawing
Indicator Connectors	Specific: Per outline drawing
Indicator Interface	Specific: BCD-coded digital
Antenna Form Factor	Specific: Two described choices
Antenna Function	Specific: Pattern coverage and polarization
Antenna Interface	Specific: VSWR $\leq$ 1.5:1 into 50 ohms
RF Cable Loss	Specific: $\leq$ 5 dB
Antenna Isolation	Specific: At least 40 dB
Antenna Power Rating	Specific: 3 kW peak
Unit Weights	Guidance: (Expected ranges) Interrogator - 10 to 25 lbs Control Panel - 1 to 2 Indicator - 1 to 2 Antenna - 1 to 2
Interwiring Interface	Specific: Pin connections per attached drawing
Primary Power Input	Reference: 115 Vac, 400 Hz 1Ø, per MIL-STD-704 (Cat. B)
Circuit Protection	Specific: Single 2A circuit breaker
Power Control Circuitry	Specific: On/off switching not to be included in the unit
Common Ground	Guidance: May be chassis-grounded; not for ac returns
Common Cold	Guidance: Not for grounding purposes
Standard Output	Specific: Output characteristics are standardized, including serial, digital distance signal. 26 Vac 400 Hz required for instrument drive
Aural Output	Specific: Aural output for positive identification

J. ARINC Characteristic 568-3, "Mark-3 Airborne Distance Measuring Equipment" (continued)

Parameter/Element	Requirement
RF Power Output	Specific: 30 dBW
Functional Test	Specific: Optional methods
Integrity Monitoring	Guidance: Undefined but recommended
Interference Rejection	Specific: No damage from +20 dBm signal; degradation limits from pulsed signal
Suppression Pulses	Specific: Suppression pulses provided to other pulse equipment when transmitting, accepted when receiving (used when dual systems are installed)
Multipath Susceptibility	Specific: Maintain lock-in with reflected energy of -10 dB (referenced to direct signal)
"Standard" Control Panel Form Factor	Reference: ARINC Report 306
Control Panel Receptacles	Specific: Two Cannon DC-37P (or equivalent)
Receptacle Locations	Specific: Rear centerline per drawing
Controls	Reference: ARINC Characteristic 547/568 and specific functions
Integral Lighting	Specific: Any combination of 26V or 5V power, ac or dc, with customer choice of red or white

K. RTCA Document DO-131, "Minimum Performance Standards - Airborne ILS Localizer Receiving Equipment"

Parameter/Element	Requirement
Receiver VSWR	Specific: $\leq$ 10 over 108.0 to 112.0 MHz
EMI Emissions	Reference: RTCA Document DO-108 (now DO-138)
Warning Signal	Specific function with undefined configuration, "easily discernible warning indication"
Antenna Efficiency	Specific: Forward and rearward pattern not more than 10 dB less than standard dipole
Antenna Polarization	Specific: Horizontal at least 10 dB over vertical
Antenna VSWR	Specific: $\leq$ 6:1

K. RTCA Document DO-131, "Minimum Performance Standards - Airborne ILS Localizer Receiving Equipment" (continued)

Parameter/Element	Requirement
Environmental Tests	Reference: Performance during (or after) tests per RTCA Document DO-108 (now DO-138)

L. RTCA Document DO-132, "Minimum Performance Standards - Airborne ILS Glide Slope Receiving Equipment"

Parameter/Element	Requirement
Receiver VSWR	Specific: $\leq$ 10 over 329.0 to 335.3 MHz
EMI Emissions	Reference: RTCA Document DO-108 (now DO-138)
Warning Signal	Specific function with undefined configuration, "easily discernible warning indication"
Antenna Efficiency	Specific: Forward pattern not more than 15 dB below standard dipole
Antenna Polarization	Specific: Horizontal at least 10 dB over vertical
Antenna VSWR	Specific: $\leq$ 6:1
Environmental Tests	Reference: Performance during (or after) tests per RTCA Document DO-108 (now DO-138)

M. RTCA Document DO-138, "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments"

NOTE: The following tests are detailed in the document, with various categories of environmental severity relating to different aircraft types and installation locations. The equipment manufacturer may select the categories for which he wishes to qualify his equipment and must indicate these categories on the equipment nameplate.

1. Temperature and Altitude
2. Humidity
3. Vibration
4. Audio Frequency Magnetic Field Susceptibility
5. Radio Frequency Susceptibility
6. Emission of Spurious RF Energy
7. Explosion
8. Waterproofness
9. Hydraulic Fluid
10. Sand and Dust
11. Fungus Resistance
12. Salt Spray

APPENDIX H

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ARINC Research Corporation evaluated the feasibility and potential cost benefits of developing and applying ARINC Characteristic-type TRACALS specifications for a future Advanced Landing System (ALS) avionics procurement. This report presents the results of the evaluation; it describes the commercial air carriers' procurement process and the role of the Characteristic, comparing elements of military procurement with parallel elements of commercial procurement.

Performance characteristics of military and commercial equipments are

evaluated, and cost and reliability comparisons are made on the basis of available data. Problem areas associated with military use of the commercial process are also discussed, with emphasis on equipment-installation problems. Finally, a recommended approach to developing an ALS Characteristic is presented.